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Study the Steel Industry

It Tests Machinery and Maintenance

. . . 'Round and 'round the test track go the motor cars, hour after hour and day after day at top speeds. Extremes of usage are intentionally being produced so that weak points in design and construction will be revealed.

. . . The iron and steel industry is the test track for men and machinery. Hot metal and heavy duty combine with scale, dust and hurry to bring out the weak points if there are any. No other industry demands as much in the way of skilled maintenance and upkeep from the Services-to-Production as does that of iron and steel. It represents the extreme of hard usage, industrially.

. . . The iron and steel industry is the test ground of maintenance and upkeep. It is a good industry to study if you want to find out how to keep electrical and mechanical equipment running at top-notch speed, without shutdown. That is why we have made this an "Iron and Steel" number of *Industrial Engineering*. And to make it even more instructive to the Services-to-Production, we have chosen for our description of methods what is probably the most highly intensified example of productivity in this intensified industry—the making of sheets by the continuous process as developed by the American Rolling Mill Company.

. . . So highly mechanized is this continuous process that a twenty-five minute delay, caused by shut-down, will cause as much loss as a forty-eight hour shut-down in a sheet mill of conventional type of similar size. Thus machinery has assumed a much more severe and responsible production burden, and naturally the importance of maintenance and the responsibilities involved in the Services-to-Production are increased in like proportion.

. . . Plant engineers and the industrial electricians will do well to study the methods employed for meeting these responsibilities in this advanced steel plant. For while it is an extreme case of intensified production in a highly intensified industry, the conditions prevailing are prophetic of what will be found in most big industries a few years hence, when mechanization extends through the further application of the continuous process idea. And the Services-to-Production must look ahead and be ready for the bigger job when the time comes.

In the new Armco continuous sheet mills, thirty-three men can produce as much as four hundred and eighty did by the old methods.

Continuous Process Methods Multiply Maintenance

TAKE THE SLACK out of industry! That is modern efficiency. It spells economy, service, and savings. The elimination of non-productive time in the handling of process material has been the dream of industrial leaders. The genius of creative invention, which marked the past decade, now finds expression in more intricate details, and today it is not so much a matter of developing new equipment as it is the development of ideas that will bring that equipment together to provide a continuous flowing stream of production.

Every invention is a journey into the unknown. Every effort of true progress, such as the development of continuous process methods, finds the doubters looking on with caustic comment. But the engineer lives in a world of related facts, not opinions. Selecting these facts, he builds his pattern by setting in this fact, fitting in that one, until the mosaic is complete and a new mechanical process is born.

As far as industry in general is concerned the continuous process is not a revolution so much as an evolution. Many industries today have unconsciously adopted the first steps in continuous production. A more detailed application of intense mechanization in the handling of material, plus the typical American determination to make things better today than they were yesterday, has been the secret of this tremendous movement. Back of all this progress are the decisions of management which, carefully balancing the hazards of business, must release the energy of organization and finance to build the idea into definite accomplishment.

The paper making industry was one of the first to develop a continuous process method. Much individual handling was finally evolved into two simple handlings, the first, where the pulp is put into the machine, and the second, where the finished product is taken out. Twenty-five years ago a young engineer, brought up in a paper mill, visited a sheet mill for the first time, and stood in amazement, observing the tremendous amount of hand work and labor necessary in the production of sheets. He counted twenty-two separate handlings, each slow and laborious. These twenty-two operations, in a way, had points of similarity with the process in the paper industry, which was performed in two handlings. If such intense mechanization was possible in the manufacture of paper, why was it not

The trend toward continuous processes in industry means increased responsibilities for the services-to-production in electrical and mechanical upkeep.

Responsibilities

By JOHN H. VAN DEVENTER
Consulting Editor
Industrial Engineering

possible to utilize a similar idea in the manufacture of iron and steel sheets? As this young engineer contemplated its possibilities, he said: "This is the place for me," and thereupon he dedicated himself to working out the continuous production process for the manufacture of iron and steel sheets. The continuous sheet mill, once a dream in the industry, eventually became an established fact.

For years and years the iron and steel industry had labored along on the same old methods in the manufacture of sheets. All improvements had been directed toward better machinery and equipment and the production of a better quality of sheets, rather than any definite attempt to change the basic method of operation. Under such conditions production was necessarily limited to standard multiples of hand mills and skilled operators.

The picture of the first successful continuous, mechanical process for rolling of iron and steel sheets was laid out on a drawing board. It was a creation of imaginative thinking, covering a period of more than fourteen years. The advice and counsel of plant engineers, plant operators, and experienced workmen, alike, were sought. Rome was not built in a day, and the continuous mill was not conceived over night. When it was decided that a continuous mill was possible immediate steps were taken to study all that had gone before on the subject, not alone in the iron and steel industry, but in allied industries as well. More than this, the methods of hand rolling, known as the old Welsh process, which had been largely handed down from father to son, were also made the subject of most intensive research. The "why this" and the "why that" of hand rolling were set up and coldly scrutinized by analytical engineering minds.

Temperatures reflected in color of the hot iron fade into infinite degrees. Each tell a story of "temperament" in the working of the metal. And hot iron has "temperament" of a wild nature. It can be made to do things, or it can be as balky as a mule, and the variables bringing about this conflicting disposition of an apparently inanimate substance are as numerous as the equations of calculus.

Hot metal from the blast furnace to finished sheets became an established fact. Precedent, dating as far back as 1750, was upset and tradition of the industry was set aside, as the real fundamentals of rolling sheets were discovered and the control

of these actual fundamentals invented.

In accomplishing this the investigation required infinitesimal measurements running into ten thousands of an inch, for it was learned that even such minute variations had a profound influence on the process. The problem was also made more difficult by the fact that when hot iron passed through a pair of rolls, the heat, itself, set up variables that had to be accurately charted, necessitating the measurement of temperatures of revolving rolls, as well as of material being worked upon them.

Items previously considered insignificant suddenly loomed large, and accepted theories had a way of vanishing in thin air. What actually took place between a pair of rolls, working on wide sheet metal, was not well understood. Painstaking investigation over a long period finally developed a method of controlling the successive passes through tandem mills with the proper reduction of the sheet on each pass. This discovery opened the door to new possibilities in the continuous production of sheets and its perfection has resulted in a final delivery of a ton of sheets a minute "without let or hindrance."

At the Ashland, Ky., plant of the American Rolling Mill Company, where the first continuous mill was built, there is a mile and a half of unbroken continuous operation, beginning with the blast furnaces and ending in the final finishing rooms and warehouses. The hot metal from the blast furnaces is poured into the open hearth, where further purification takes place. The metal is then poured into huge ladles and teemed into ingot molds. The ingots are brought to a uniform heat for rolling and sent on their way through the ponderous rolls of the blooming mill, which convert them into heavy slabs that are carried by roller tables and fed into the first of a series of reheating furnaces; to be sheared into lengths as required.

The continuous process requires that the sheet mills be placed one after the other, with long heat-holding furnaces coupled to each stand of rolls. In the old hand process, the mills were placed side by side with the furnaces opposite. Reaching into these furnaces with the long tongs, the operator dragged the sheet bars to the mill where he inserted them in the rolls. An operator on the other side received the piece as it came through and sent it back over the top of the roll. This process continued until the bar was "roughed down" when it was dragged back to the reheating furnace for further conditioning. Again it was removed and passed back and forth through the finishing rolls, doubled and rolled in packs in order to get the required thickness. Eight men made up the crew on each mill, and the work was so arduous and the heat so intense that the work proceeded in 15-min. shifts. On hot, stifling days it was a drawn and haggard crew that fought like thoroughbreds to keep the mills going.

Contrast this picture with the continuous sheet mills where but 33 men are required to produce as much as 480 men, by the old method, every 24 hours. Nor is the work of these 33 men physically hard. The straining muscles of arms and back give way to the wrinkled brow as skilled judgment watches over the operations.

Emerging from the blooming mill, in the continuous process, the slab ducks its head through first one and then another of the huge mills, placed in tandem formation, each giving it a loud "spank" as the bar goes through on its swift journey.

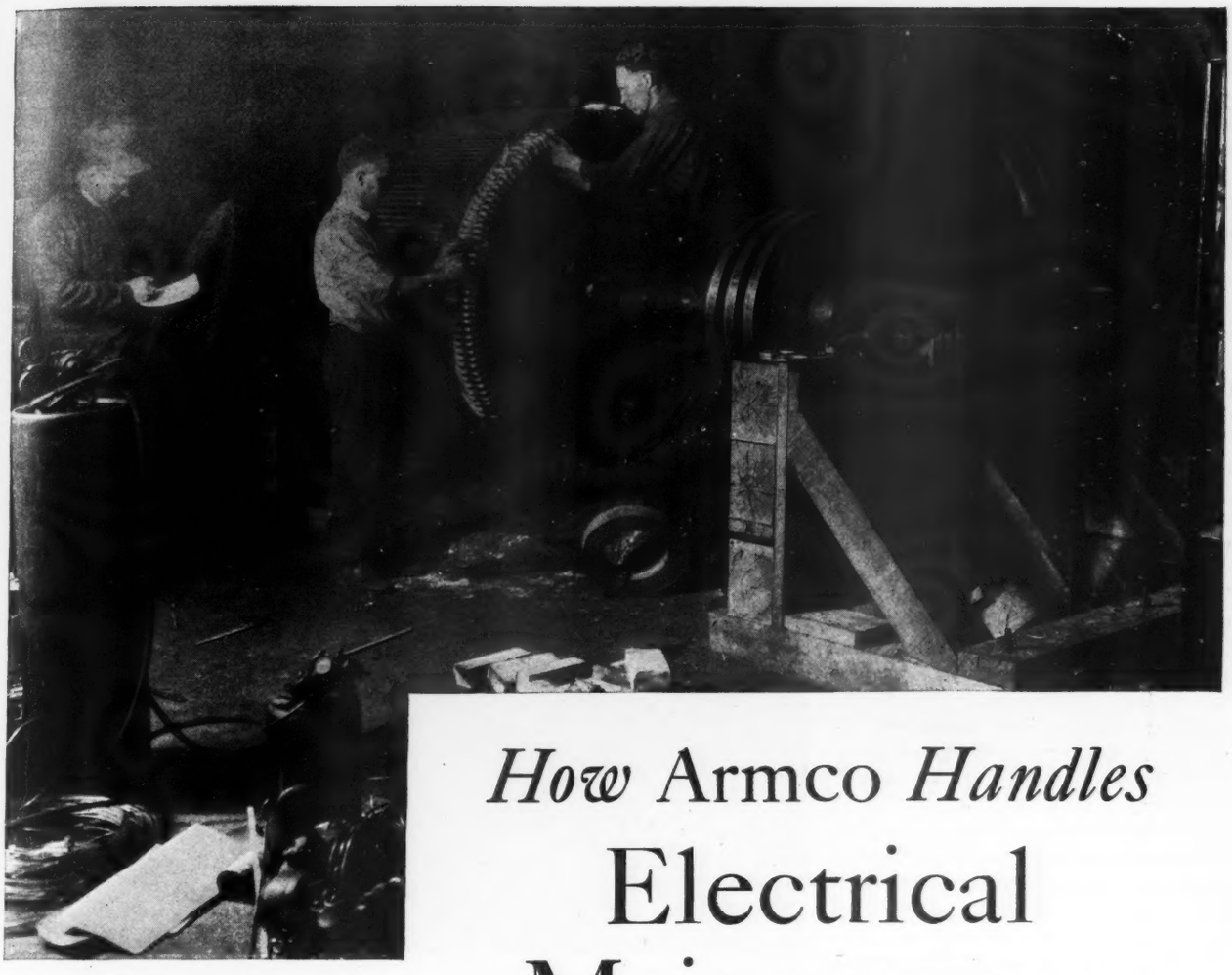
Another tunnel of heat to go through and another series of rolls—one after the other—clank! clank! clank! To follow this piece of iron throughout its processing one has to trot briskly along side of it, mentally calling "hello" as it appears momentarily, only to disappear again.

The sheets, more or less cooled in the process, come sliding out at the end of the journey like black, sleek, well-trained seals. Here the way divides. Some sheets take the road that leads to the "high finished" world of automobile and furniture, others follow the path to the black sheet and galvanized world. If sheets are to become a high finished product they are passed through stitching machines, which, by quick, deft action, fasten the sheets end-to-end and the ribbon-like caravan continues, looping up and down over gigantic rollers emerging at last into a broad, well lighted finishing room where the stitches are cut apart and the sheets sorted to do their work in the world. In this brief journey of a mile and a half, the red iron ore of the mountain has become metamorphosed into sheet metal for ramified service to mankind.

Continuous mill operations in the iron and steel business today take two forms: the rolling of wide, thin sheets, just described, and the rolling of wide, thin strips. These two outstanding developments have been brought together under the banner of the American Rolling Mill Company.

The contribution which Armco made to the industrial world was only possible because of the remarkable spirit of co-operation outside as well as within its own ranks. After all, a great steel plant is but the composite of hundreds of manufacturers, whose cranes, gears, electrical apparatus, power generators, engines, and what else, are synchronized into complete and effective production. Mr. George M. Verity, president, and his close associates have been vigilant throughout the twenty-eight years of Armco's history in promoting a real understanding among the men of the organization and industry in general. At every turn of the road he has pointed out the interdependence, one with the other—the workman, the management, the stockholder, and the customer—that make up the four corner stones of successful industrial undertakings. The continuous sheet mill is the indirect outgrowth of this unified enthusiasm, courage, and determination. It is a striking example of the economies that may be expected to follow the inevitable development of the continuous process idea in other industries.

The articles which follow this description of the continuous process of sheet steel making will show how the Armco Services-to-Production are geared up to cope with the enlarged responsibilities of the faster pace. Before reading them we suggest that you turn to the pictorial presentation of the continuous process of sheet steel making, as given on pages 285-288 of this issue. This will supplement the preceding text description and will aid in the interpretation of the remaining articles on electrical and mechanical maintenance and safety.



REPAIRS to big motors and other equipment are made out in the mill. Here a repair shop gang is rewinding the rotor of a 2,000-hp. motor in the Jobbing Mill.

How Armco *Handles* Electrical Maintenance Work

By G. A. VAN BRUNT

Electrical Editor
Industrial Engineering

UNDER any circumstances, trouble-free operation of electrical equipment is a very important element in securing the lowest operating and production costs, and is highly desirable from every standpoint. When continuous-process operation is involved, failure of any element of the electrical equipment is little short of disastrous; the whole train of operation is shut down.

That is the condition with which the maintenance department has to deal at the Middletown, Ohio, Ashland, Ky., and Butler, Pa., plants of the American Rolling Mill Company. Despite the severe service to which all steel mill equipment is subjected, it must be kept going with the absolute minimum of trouble and delays. How this is accomplished through rigid inspection and prompt attention to all weak spots will be described in this article. For the sake of simplicity, the details of the procedure followed at the Ashland plant will be given, which, with some minor differences in organization, is the general plan followed at all the Armco plants.

Considering for a moment the amount and character of the electrical equipment used, the total connected load at the Ashland plant is 41,028 hp. in motors, which range from ¼- to 3,250-hp. rating. To carry this load there is installed 22,275 kva. capacity in transformers, and 5,575 kw. in direct-current generator capacity. The various mills and departments are served by a total of 43 traveling cranes.

Power is delivered at 33,000 volts, three phase, 60 cycles. Outside the substation it is stepped down to 6,600 and 2,300 volts by three banks of 2,000-kva. transformers. A spare 33,000/6,600/2,300-volt transformer mounted on truck wheels is kept for emergencies. After entering the substation a portion of the power is again stepped down to 440 volts by three banks of 1,000-kva. transformers. A portion is also converted to 250 volts direct current by five motor-generator sets with a total rating of 3,500 kw. These sets are located at various points in the plant.

The power distribution operator has control of all switching facilities

for distributing power to the various substations and control rooms. Remote-controlled Westinghouse truck-type switches, operated by a group of 125-volt Exide batteries, are used on all major circuits.

In the mill, the soaking pits are served by two 10-ton cranes equipped with a 15-ton auxiliary hoist for handling cinder boxes, and so on. A 30-ton Alliance crane with 10-ton auxiliary hoist is used for changing rolls and making repairs.

The blooming mill is driven by a G.E. 3,250-hp., 120-r.p.m., 600-volt d.c. motor with reversing control. The screwdowns are driven by two G.E. Type MD 108, 230-volt d.c. motors. Two control boards are installed, one for each motor, with a third control board as a spare for use with either motor in case of trouble. The front and back tables of the mills are driven by G.E. series-wound MD 108 motors. The other tables are driven by Westinghouse series-wound Type MC motors.

All auxiliary control panels are located in a separate building adjacent to the blooming mill. In this room there are, besides the regular operating panels, a spare panel for the screwdown motors, one spare for the sideguards and one spare for the approach table. By merely throwing switches these spares may be used instead of the regular control panels. This arrangement has been worked out to insure continuity of operation in case of trouble on any panel.

A G.E. control board is installed in the blooming mill motor room so that one roller is able to control the mill drive and screwdowns.

In this mill a 30-ton Alliance crane with 10-ton auxiliary hoist is used for changing rolls and making repairs.

The bar mill comprises seven horizontal and four vertical stands which are driven from the horizontal stands through gear reductions. The first horizontal stand is driven by a 300-hp., Type CW Westinghouse motor. The remaining stands are driven by 300-, 500- and 600-hp. motors respectively. The motors driving the first three stands in the bar mill are controlled through Westinghouse automatic control boards. Grid resistors are used in the rotor circuits. The remaining four motors are controlled by means of Westinghouse slip regulators.

No. 1 jobbing mill is driven by a 2,000-hp. motor and No. 2 mill by a 3,000-hp. motor, which are controlled by a Westinghouse truck-type control board. Westinghouse slip regulators are cut into the rotor circuit.

No. 3 mill is driven by a Scherbius set controlled through a G.E. magnetic control board. This motor can be operated either with the Scherbius regulator or without it. When the regulator is used it is possible to obtain a variable speed ranging from 240 to 360 r.p.m. above or below synchronous speed. Without the regulator the motor acts as an ordinary slipring motor with resistance in the rotor circuit.

The jobbing mill is served by a 50-ton crane with a 15-ton auxiliary hoist, and a two-hoist crane for roll changing and handling materials.

A CORNER of the tractor repair shop, showing the charging panel and stations. The charging panels which were made in the plant are so constructed that a tractor may be charged alone or three in series from one panel.

* * * *

A transfer car driven by a 5-hp., three-phase, 440-volt slipring Warner Elevator Company motor and control handles scrap in the scrap hole.

In the jobbing mill warehouse building, where all stock is handled from the jobbing mill, there are two 15-ton Morgan cranes, each with a bridge span of 110 ft. Westinghouse motors and control equipment are used on these cranes, which have a bridge travel of 300 f.p.m. It is the duty of these cranes to deliver the output of the jobbing mill to the shear building, levelers, open annealing furnace, No. 1 or No. 2 sheet mill, and the jobbing mill plate pickler.

In the plate pickling section of the jobbing mill there are two Morgan cranes of 10-ton capacity. These cranes are operated from a pulpit on the floor, on account of the large amount of fumes present in the air. These cranes deliver sheets from the jobbing mill warehouse to the jobbing mill plate pickler. In this department two Ironton Engine Company 4-ton battery locomotives are also used to transfer sheet trucks to this building.

Adjacent to the jobbing mill warehouse is the shear building containing levelers, rotary shears, cut-off shears, resquaring shears and the sheet scrap bundling machine. All machines here are served by a 20-ton Morgan crane equipped with Westinghouse motors and control.

A unique feature of this crane is the fact that it is controlled from a pulpit mounted three feet above the floor, through a collector rail system. All of the control equipment is located in a control room adjacent to the shear building. Material routed through this building is transferred to the finishing section by two Baker R & L battery tractors driven by 42 Edison A-8 cells.

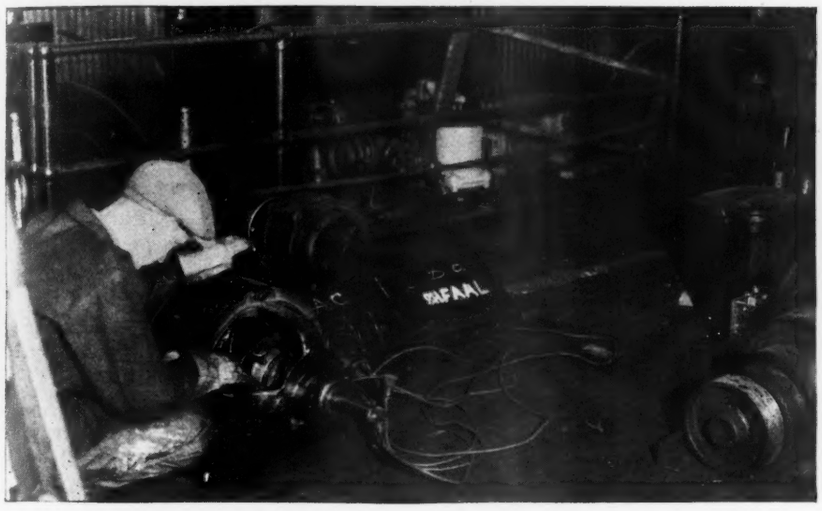
In No. 1 sheet mill Westinghouse primary panels are used on all main motor drives, with Westinghouse slip regulators in the rotor circuit. The control room is located adjacent to the sheet mill about midway of the building. In this control room there are three banks of Westinghouse 120-kva. static condensers for power factor correction.

The No. 2 sheet mill differs from the No. 1 mill in that sheets are rolled cold. In view of the absence of smoke, dust, dirt and fumes, the motors and motor-generator sets are located in the open.

This building is served by a 40-ton Morgan crane completely equipped with Hyatt roller bearings. Sheets are handled from here to the sheet mill warehouse building which con-

tains rotary and cut-off shears. A portion of the material from this building is handled by Baker R & L battery tractors to various parts of the finishing section. The remainder of the material is routed to strip picklers which are located in an adjacent building.

The cold rolling building contains eight mills, seven of which are driven by Westinghouse 300-hp. slipring motors and the last by a 400-hp. slipring motor, through Falk single-reduction speed reducers. In this building two crane runways are installed paralleling each other. Each runway carries a 15-ton Morgan crane. These cranes are of the older type and are not equipped with roller bearings.



MOTORS are checked up by a running test before they are put back into service. To facilitate testing, leads have been run in conduit from a test board at the right to conveniently located power outlets, as shown here.

The battery tractor repair shop and battery charging room are located between the shipping and warehouse building and the galvanizing department. In this building all repair work and charging of the eleven Baker R & L tractors and three Elwell Parker tractors is carried on. The maintenance on all tractors and battery locomotives is handled by one man on each eight-hour shift. A boosting charge is given for one-half hour at noon and again at midnight. Full-load charging is done at night. The charging panels are supplied with direct current at 230 volts, taken from the crane service supply. These panels, which were made in the plant, are constructed so that a tractor may be charged alone or three tractors charged in series from one panel.

There is enough capacity available to charge nine batteries at one time. Two sets of batteries and trays are kept repaired and charged for emergency use. The tractor repair man handles all battery charging.

Responsibility for electrical maintenance and repair work is vested in the superintendent of electrical maintenance. Next in line comes the electrical general foreman, who bears responsibility for maintenance of all electrical equipment. Direct contact with, and supervision over, all electrical maintenance activities are secured by one general foreman. In all, there are six section and one shop foremen supervising electrical maintenance work.

In the electrical organization, one section foreman covers what is known as the 23rd Street works territory and the 6th Street mechanical shop, foundry and blast furnace. He is in charge of 13 men.

* * * *

The foreman in the open hearth department has 34 men, including crane operators, under him. His responsibility covers all electrical equipment, including stockyard ladle cranes, floor chargers, hot metal cranes and hot metal mixers.

The section foreman in the blooming and bar mills supervises 29 men, including the crane operators.

Fifty-four men, including the crane operators, are required to handle the maintenance work in the jobbing mill, jobbing mill warehouse, plate picklers, No. 1 and No. 2 sheet mills and sheet mill warehouse.

In the finishing section, strip pickling, cold rolling, stripping warehouse, continuous box annealing and galvanizing departments, there are 31 inspectors and crane operators.

The electrical shop foreman is in charge of the repair shop work for all sections. He is in charge of 16 men including control repair men, armature winders, lathe hand and toolroom boy.

In addition to the foregoing, there is a section maintenance foreman whose responsibility covers the entire yard, power distribution station and tractor repair shop. He is in charge of all new installations and construction work. His force comprises 36 men, including extra crane operators, yard inspectors, linemen and the crane repair crew, which is subject to call anywhere.

Depending on the section, an inspector may have an A, a B, or a C man under him as helper. In most of the sections, however, the inspector is considered as the A man.

As the inspection work is organized at present, all crane operators are responsible to the motor inspector on that turn.

The motor inspector makes a daily inspection of all equipment, including the cranes, table motors, and so on. If any defects or trouble is discovered it is noted on his report, with the records of all repairs that have been made, as well as recommendations for future changes or replacements. These reports, one of which is shown in the illustration on page 276, are received each day by the section foreman of that division and then sent to the electrical maintenance department where they are again looked over. If any important changes or repairs have been made they are recorded by the spare parts department, which is responsible for keeping an adequate amount of spare parts for all equipment.

From the daily record which he receives from each inspector, the foreman of that section makes out the report shown on page 276, which represents a summary of the work done in that section. The foremen keep these reports until the end of the week, at which time all of them meet in conference and work out plans for handling the big jobs that must be done over the week end.

The foremen's reports are then turned in to the electrical maintenance department.

All motor and armature changes are recorded and checked against previous records of service, giving a perpetual record of performance of that piece of equipment. A record of each motor is kept from the time the motor is purchased, no matter where it may be installed. If there are too frequent changes of arma-

tures or too many motor breakdowns, the record will show it. Then a test is recommended and conducted by the general foreman, the section foreman or a test man.

Portable test and recording instruments are kept in the electric repair shop. Results of all tests are entered in the motor record and kept in the office of the electrical maintenance department for future reference.

No periodical load tests are made on auxiliary motor drives, but all main drive motors are equipped with recording instruments whose charts are removed and sent to the electrical superintendent's office for checking. Weekly inspections are made and insulation resistance tests are conducted on the large main drive motors by the electrical shop crew.

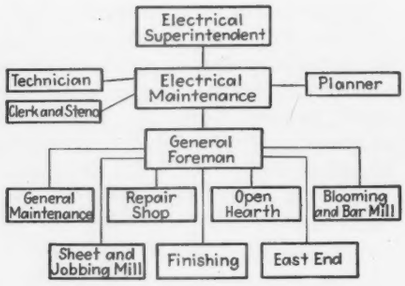
The results of all such tests are sent to the electrical superintendent's office for checking and recording.

All oil switches controlling the large motors are given a monthly inspection, any necessary repairs made and the oil given a breakdown test. If the oil does not show the proper breakdown value it is run through a filter. This work is done by the general maintenance section. A report of these tests is sent to the superintendent of electrical maintenance.

To prevent excessive overloading of any individual drive motor, ammeters have been put in in the secondary metering system. These ammeters are mounted within sight of the roller who supervises the distribution of loads. Obviously, this plan indirectly assists in reducing maintenance, as data are given these rollers as to the current capacity of the motors so as not to exceed the rated loads.

* * * *

ON THIS REPORT the motor inspectors record all defects or trouble found, with details of repairs that were made.



ORGANIZATION CHART for electrical maintenance department.

* * * *

When trouble occurs on a mill, the motor inspector is called. A signal system is installed for this purpose and is available to rollers, shearmen and helpers so that no time will be lost in getting service. When the motor inspector hears this signal he comes on the run. From his inspection he determines whether the trouble is of an electrical or mechanical nature. If it is of electrical origin he finds the cause and if he can remedy it by himself he does so. In case he needs help he sounds the Alamo emergency signal, which will probably be answered by the section foreman, who will go at once to the location indicated and then determine just what method to pursue in making the repairs.

In an effort to simplify and reduce the maintenance required by motors on important drives, an interesting experiment is being conducted. The coil ends on rewound rotors for these large motors are now left without insulation. The old practice of attaching insulating hoods over these coil ends is being abolished as a result of these experiments. Now the coil ends may be inspected weekly for poor connections or other faults that may occur. If this practice is successful the coil ends on the rotors and armatures on all main drive motors will be treated likewise.

It is felt that this procedure will cut down maintenance cost considerably by reducing the amount of insulation and labor required and will make it possible to reduce the number of rewind jobs, as defects will be more readily detected. In addition, the time delay occasioned by the necessity of rewinding will be reduced, thereby boosting production.

In maintenance work, as in everything else, the results obtained are the best measure of the efficiency of an organization and its method of working. On this basis it is interesting to note that during the past nine months the delays in the jobbing mill, which is one of the most important in the plant, averaged 1 hour and 47 minutes per month, or a total lost time of 16 hours and 3 minutes. The total number of hours of operation of this mill for the same period was 3,316 hours.

The reason for such a fine record from the standpoint of lost time is due to the thoroughness with which maintenance work is conducted. For example, rather than wait for a breakdown, mill motors are torn down at intervals of six months for a complete inspection to detect loose wedges, banding or connections, bad coil joints or bearings, and other defects. It has been found that although this practice increases the cost of electrical maintenance work on continuous-process equipment, it pays to do it on a large scale. It is estimated that at least six rewinding jobs on the 2,000-hp. jobbing mill motor have been prevented by this method of inspection.

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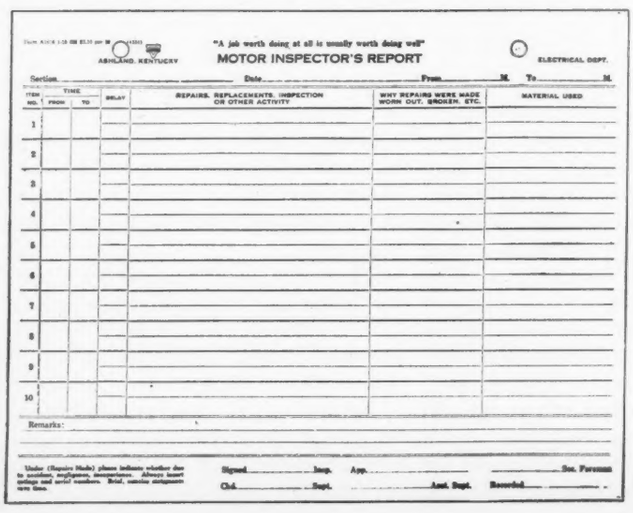
THIS REPORT is made out by each section foreman and is a summary of the work done by the men under his charge.


"A job worth doing at all is usually worth doing well"

ASHLAND, KENTUCKY

MOTOR INSPECTOR'S REPORT

ELECTRICAL DEPT.

Section _____ Date _____ From _____ M. To _____ M.

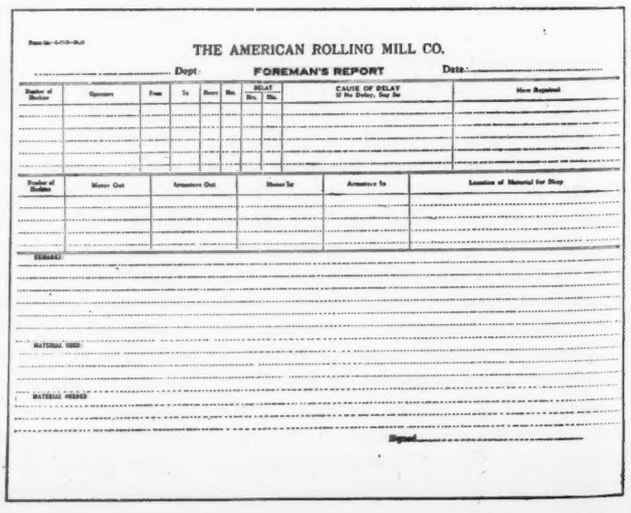
ITEM NO.	TIME FROM	TIME TO	DELAY	REPAIRS, REPLACEMENTS, INSPECTION OR OTHER ACTIVITY	WHY REPAIRS WERE MADE WORN OUT, BROKEN, ETC.	MATERIAL USED
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Remarks: _____

Under (Repairs Made) please indicate whether due to accident, negligence, inexperience. Always insert castings and serial numbers. Brief, concise statements save time.

Signed _____ Insp. App. _____ Sec. Foreman

Chk. _____ Supt. _____ Asst. Supt. Recorded _____


THE AMERICAN ROLLING MILL CO.

Dept. _____ FOREMAN'S REPORT Date: _____

Number of Heaters	Operators	From	To	Hours	DELAY Hrs.	DELAY Min.	CAUSE OF DELAY If No Delay, Say So	Men Required

Number of Heaters	Motor Out	Armature Out	Motor In	Armature In	Location of Material for Shop

REMARKS:

MATERIAL USED:

MATERIAL NEEDED:

Signed _____

The pipe shop and riggers shop at the Ashland, Ky., plant, one of the five shops which facilitate mechanical maintenance.

Organizing Mechanical Maintenance *for* Armco's *Continuous Process Mill*

A HALF-HOUR shut-down for repairs may mean little or much, depending on reserve capacity and on the flexibility of the production process. The older, hand labor method of industrial production is flexible—but slow. The modern, mechanical method is faster and cheaper, but less flexible. As a consequence, the more we increase mechanization, the more important becomes the function of forestalling and minimizing shut-downs due to mechanical failures.

A half-hour shut-down of the continuous process sheet mill at Ashland, for example, involves a production loss equal to two days' production by any ordinary sheet mill of the same size. Since the market for its product is such as to warrant operating this mill on three 8-hr. shifts, 24 hr. a day, the vital part of mechanical maintenance in the scheme of operations is apparent.

By W. THOMSON LEES
Industrial Editor
Industrial Engineering

In developing the maintenance organization for its continuous process mill, the company built upon the foundation of its experience at the Middletown plant; making such changes as proved expedient to conform to the different conditions.

Each plant has its own fully articulated independent Maintenance Department. At Middletown there are three divisions, Electrical, Mechanical, and Power; at Ashland there are two, Electrical and Mechanical. Experience in the older mill had proved the practical worth of a scheme of organization on the basis of unit responsibility, and the same type of organization has been set up for the Ashland plant.

Maintenance as a whole is split up into three main divisions: Electrical, Mechanical, and Power. In the present discussion we are concerned only with the Mechanical Divisions, at Middletown and at Ashland.

In the Middletown plant is a machine shop devoted exclusively to mechanical maintenance and repair work. The equipment in this shop includes a 10-ft. boring mill, shaper, twelve lathes, ranging from 12 in. to 42 in., automatic gear cutters, grinders, radial drill presses, planers, a 300-ton hydraulic wheel press, and miscellaneous small tools. The shop is served by a 40-ton crane, and is equipped to handle any work from a few ounces to 50 tons; in fact, it is as well equipped as any general jobbing machine shop in the vicinity. Forty-four men are employed in the machine shop division.

In addition, the following shops are a part of the maintenance facilities at Middletown: A carpenter, paint and tin shop, employing 24

A GAS FIRED unit heater in the sheet mill at Ashland, Ky. A more elaborate system is used in the finishing warehouse.

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men; a blacksmith shop with 24 men; pipe shop, with a force of 18 men; rigging shop, employing 37 men. A construction gang of 10 men; a roundhouse and car repair crew of 41 men; the open hearth mechanical maintenance force of 15 men; the blooming and bar mill force of 31 men; the sheet and jobbing mill maintenance force of 52 men; these complete the mechanical maintenance units at the Middletown plant.

There is a responsible foreman in charge of each group, the larger units having assistant foremen as well. The latter are developed from the ranks, according to native ability; the key thought being to develop foremen for the normal program of expansion and promotions. For example, the general foreman on the Ashland work came from the Middletown sheet mill, where he had been head foreman; the then machine shop foreman took his place, and the assistant foreman of processing maintenance became machine shop foreman.

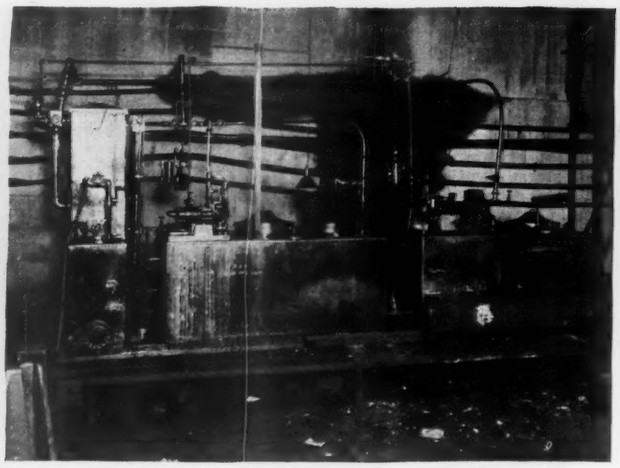
The mechanical maintenance force at the Ashland mill, where the continuous process was put into successful operation, is organized along similar lines. Each division (Blooming and Bar Mill, Job Mill, Sheet Mill, Strip and Galvanizing, and Finishing Mill) has its own unit organization. Here, there are 109 men, including inspectors, helpers and oilers, in charge of five divisional foremen and one general foreman. Continuous 24 hr. service is given, in three 8-hr. shifts.

Since a hitch anywhere along the line is likely completely to disrupt the continuous process, the responsibility on the maintenance department at Ashland is correspondingly severe. It calls for both efficient organization and intelligent practice.

Each 8-hr. shift of each unit makes out a report, which is read by the general foreman and is then sent to the superintendent of maintenance. These reports are then filed for future reference. The foremen report all trouble encountered, equipment that might fail and which they could not put in shape, delays, and so on. Reports of this kind stimulate the foremen to study the causes of mechanical failures, and help to eliminate future failures. At the same time, they tend to bring out all there is of latent ability and ingenuity.

On the various maintenance jobs in the continuous process mill, the helpers are directed by inspectors; the latter being millwrights and actual key men for each unit. The oilers' work is routine, under supervision of the inspectors. Pipe fitters, working on water, steam and air lines, work under the inspectors' supervision; and if a job of this sort proves too big for the pipe fitters' gang, they call on reserves from the shop construction maintenance gang.

In the case of emergency repairs, for example in the jobbing mill, if the blooming and bar mill is shut down, the maintenance gang of that unit is called on to reinforce the job-



OIL FILTERS and pumps used in the oil circulating system on the bar mill engine and hydraulic pumps.

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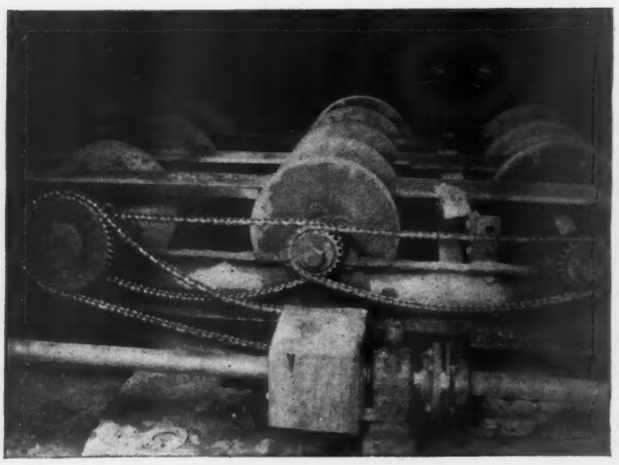
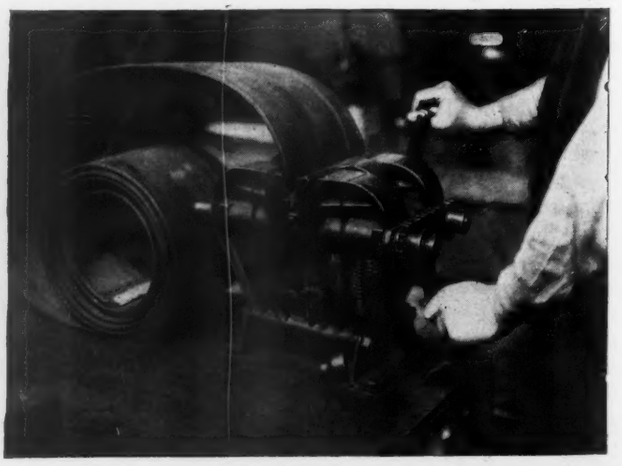
A JOB worth doing is worth doing well; hence this up-to-date belt joining equipment.



LUBRICATION and inspection are vital on equipment of this type, serving continuous production.



A CORNER of the carpenter shop, which (at Middletown) is combined with the paint and tin shops.

PART of the general stores bins for small parts. Perpetual inventory system keeps a constant check on spares.

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bing mill maintenance crew; if a sheet mill is shut down for emergency repair, maintenance men from the other sheet mill are pressed into service, and so on.

A typical instance of emergency repair was in the case of a break on the 2,000 hp. jobbing mill drive. The primary housing on the reduction gear had split between the low and high speed shafts and the high speed bearing pedestal was knocked loose from the foundation. The emergency crew assembled 20x16-in. plates fastened together by means of separators, made socket bolts to attach on to foundation bolts, placed beams across slow speed to high speed pillow blocks, and bolted down to foundation bolts by means of the socket bolts. The high speed bearings were tied down solid to foundations, to prevent the housing from spreading and allowing the gears to unmesh. Twelve men accomplished this job in 3 hr. and 20 min.

It is worthy of note that the men who handled this kind of work were not, in the main, experienced; many of them had never done any mill work before. It is the system of organization and training, that not only makes them efficient, but that provides foremen for new jobs as they arise. The labor turnover is extremely small, less than 9 per cent, and the chances for promotion undoubtedly are a factor in this.

As previously stated, the maintenance department gives 24-hr. service, in three 8-hr. turns. Each shift, or "turn," is in charge of a leader. A chief inspector makes the rounds continually, noting on blank paper any observed defects. If attention is not needed immediately, these notations are kept for incorporation among repairs to be attended to over the week-end. In case immediate attention is required, a shop order is made out, the foreman gets in touch with the shop, and work is at once begun in whatever fashion best suits the conditions involved. If a spare part is available, it is put in, and the worn or defective part is removed and sent to the shop for repair.

Each of the major maintenance divisions keeps a perpetual inventory card system on every spare part; a duplicate of each card being kept in the file at maintenance headquarters. When a spare part is used, another is automatically requisitioned to take its place in spare stock. If any item shows inactivity, it is an indication that the spare stock on that item may well be reduced. Once each month, there is a check-up on spare parts stock.

In the case of defects noted, but not requiring immediate attention, the sheets recording these are typed and are brought to the weekly conference. This conference is called by the Superintendent of Main-

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POURING babbitt bearings. Note the protection for the man's face, in case of flying hot metal.

tenance, and is attended by the divisional foremen. Here, the accumulated reports from inspectors and foremen are brought up for discussion and planning, work is laid out for the week-end (when the mill is shut down) and safety features are discussed. Wherever maintenance or repair work involves holding up production, the job (unless an emergency) must be done between 8 a.m. Saturday and midnight, Sunday.

These meetings, in addition to keeping the chief of the maintenance forces in closer touch with conditions, make for better co-ordination of effort. For example, where both the electrical and the mechanical divisions are to work on a crane, the division heads decide which shall start the work, while the other division crew is engaged elsewhere; when one gang finished its job on the crane, the other takes over the completion of the work.

Safety provisions are farsighted, and the enforcement of safety rules is (and rightly so) rigid; resulting in an enviable safety record. Speed is the watchword on all repair and maintenance work, but never speed at the expense of safety.

There are maintenance headquarters located at three centers, at Ashland. At each of these is a sub-store, a branch of the general stores. Here, with 24-hr. service, all small repair material is available for routine work on the maintenance of the continuous process mills. Material is thus available quickly when needed, and general stores are relieved of the necessity for 24-hour duty. In addition to being a headquarters for supplies, these "branch headquarters" provide a central point for general repairs not

SHOP ORDER
ASHLAND, KENTUCKY

TOTAL COPIES | FOREMAN
ACCT. DEPT. | FOR FILE
SHOPS | EXTRA

To Sixth Street Shops
Please perform work as specified below and deliver
Dept. Order No. S PM-7654 DATE 5-20-28
Shop Work Order No.
To Bldg. 106 ; Door No. not later than:

QUA.	DESCRIPTION
	Machine 4 C. S. Locks, Patt. #1092-AZA, Dwg. 106-1092-49.
	Castings ordered from Middletown on S & E-1755-M.
	And will be sent to shop.
	Spare No. For; Sheet and Jobbing Mills.

Material to be furnished by:

	CHG. ACCT. NO.	FINAL COST
Labor	711-19-42,	
Mat.	711-20-52,	
Overhead		
Total		

Signed H. S. Amburgy Foreman Approved H. C. Huntsberger Supt.
Dept. Approved Gen. Supt.

GRAGER PRINTING COMPANY, ASHLAND, KY.

SHOP ORDER
ASHLAND, KENTUCKY

TOTAL COPIES | FOREMAN
ACCT. DEPT. | FOR FILE
SHOPS | EXTRA

To Sixth Street, Shops
Please perform work as specified below and deliver
Dept. Order No. S&E-1154-M. DATE 5-12-28.
Shop Work Order No. 8489
To Bldg. 106. ; Door No. not later than: Rush

QUA.	DESCRIPTION
	EMERGENCY
	- CONFIRMING -
	Forge and machine one shaft, MK (BC) on
	Dwg. 107-330-3 and assemble with center;
	ring gear and coupling.
	For; Jobbing Mill Conveyors.
	Rush, Emergency, NO SPARE.
	Spare No. 751-65.

Material to be furnished by:

	CHG. ACCT. NO.	FINAL COST
Labor	930-00-00	
Mat.	930-00-00	
Overhead		
Total		

Signed H. S. Amburgy Foreman Approved P. J. Phillips Supt.
Dept. Approved Gen. Supt.

GRAGER PRINTING COMPANY, ASHLAND, KY.

SHOP ORDER form, which is made out by the foreman and approved by the superintendent, for ordinary work to be done in the shops.

* * * *

extensive enough to require full machine shop equipment. Drill press, grinders and hack saw equipment permit handling repair work of this nature without requiring transporting parts to the main machine shop.

At these headquarters, too, the gangs congregate as the different shifts go on and off duty. There are showers and individual lockers on the second floor of the building, and spare parts stores, shop, and offices of the electrical and mechanical maintenance divisions on the first floor. Here, notices are posted, and the foremen come in contact with all of the men under them, as the different shifts or turns go on or off duty. The gang going off reports failures and conditions, and the foreman is thus able to instruct the gang which is going on to finish the job.

* * * *

WORK not requiring immediate attention is listed for week-end work, to be done while the mill is shut down. Shown here, with the week-end report sheet, is also a standard work-order form.

The general foreman has his headquarters in the middle section, permitting easy access to all parts of the plant for contact with each division. At the beginning of each 7 a.m. turn, he meets the divisional foremen and plans the day's activities, going over their reports of the previous 24-hr. operation. These reports are then sent to the spares office, and a copy is sent back from there to the general foreman, the original being filed. These reports are accumulated to compile a complete report on all maintenance operations; this being taken up with the Superintendent of Maintenance on his daily rounds.

In summing up this brief description, there is one point worth stressing. In many plants, both large and small, mechanical maintenance is still more or less of a haphazard, hit-or-miss affair, without system or organization. It is obvious that such methods could not possibly go hand in hand with the operation of continuous process mill at Ashland. At the other extreme, there are many plants where the realization of a need for organization produced systems so tied up in red tape as to be cumbersome.

IN CASE of work which must take precedence over routine, the shop order states the reason, and the word Emergency is stamped on it.

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Here, on the other hand, both at Middletown and at Ashland, the American Rolling Mills has set up an organization with the single purpose of keeping things going, and going as nearly right as possible. In its organization of mechanical maintenance, as with its other maintenance divisions, the entire structure is keyed to the main objective of rendering service to production.

In its development, wherever "system" clashed with service, system gave way to enlightened common sense. As a result both routine and emergency work are provided for; labor turnover is low, and ability on the part of the individual is not submerged or discouraged, but is recognized and rewarded; and the maintenance organization as it stands today is able to render very close to 100 per cent service-to-production.

* * * *

REPORTS are turned in each day on delays and production. A copy goes to the general foreman and the originals are filed for future reference.

MECHANICAL MAINTENANCE -- WEEK END REPORT
ASHLAND, KENTUCKY
Sheet Mill Section
Week Ending Feb. 11 1928

ITEM NO.	DESCRIPTION OF JOB TO BE DONE	PERFORMED BY	REMARKS
1	Change mills.		
2	Turn Shear Blades.		
3	Repair Furnace belts.		
4	New shaft and bearings, exit roll, D. Furnace.		
5	New plates and side guides, No. 1 Approach Table.		
6	Repair No. 2 approach table.		
7	New disc No. 4 and No. 5 shaft, D Furnace		
8	No. 3 roll, #2 furnace.		
9	Inspect square couplings and spindles.		

WORK ORDER
Date S. O. By W. O.
Charge to

THIS ORDER COST:
Labor No. $
Overhead
Service No.
Material
Total
COST DEPT. (MAIN SEC.)

Date Completed
FOREMAN

DELAY REPORT

March 12, 1928.

Blooming and Bar Mills.

Day turn started 7:00 AM. Stopped 5:40 PM Rolled 727 Tons.

Night Turn Started 6:48 PM. " 5:25 AM. " 805 "
Total Tons Rolled, 1532.
21 min delay, Hyd. jack on 6 x 30 shears.

Jobbing Mill.

Day turn started 7:00 AM. Stopped 5:40 PM. Rolled 188 Ingots. 727 Tons.
Night Turn " 6:48 PM. " 5:25 AM. " 180 Ingots. 805 Tons.

Total Ingots Rolled 336. Total Tons Rolled 1532.
30 min delay on Pack Table.

No. 1 Sheet Mill.

six min. Shortening D.Fce. Chain east end.
forty Min Broken bearing stand, #4 Rock Mill Table.

No. 2 Sheet Mill.

15 Min, Crane Spilled Lift.
15 Min, Putting side guard on pulley
9 Min, on account of iron not stacking right.

Galvanizing, Finishing, & Strip Section.

Galvanizing... 5 hrs. cleaning metallic packing bottom, steam end.

Finishing ....30 min. changing Mill.
3 hrs. two broken chains on furnace door.
30 min. Broken Gas pipe.
1 hr. 15 min. Broken arm on 30" Stoll Shear.

Strip Section..5 min. Pinch roll drive chain broke.
5 min. cutting out link, #6 Furnace Roll.

How Armco trains its men to think and act . . .

SAFETY

as told to

HALL PACKER
Editorial Staff
Industrial Engineering

This trophy is awarded annually to the group having the best safety record.

MORE than ten thousand men and women work for Armco. It is, as industries go, a large organization. Its business is the making of iron and steel sheets, light plates and cold-rolled strip, and those who are familiar with steel mills know that in them there are plenty of chances for men to get hurt. Yet, in all its many stages of manufacturing, from mining ore to the finished sheet, each stage providing its own hazards to workmen, this organization has succeeded in making some most astonishing records in its program of safety.

"Tell me, now," I said to Mr. Adair, supervisor of safety. "How do you do it?"

I was in direct contact with the headquarters of accident prevention work for the several Armco plants and, knowing something about the tremendously hard task which a safety man faces I was, naturally, more than interested in what the supervisor of safety would have to say to my "How." Before he could say a word, something happened; something that was a bit dramatic and timed to the second, to demonstrate to me the *how* and *why* of safety at these plants. The door to the supervisor's office opened, and a workman from the carpenter shop stepped in.

"I got it all fixed," he said.

"Fine!" said Mr. Adair. "How did you get it done?"

Right there you have a close-up on Armco's safety attitude—it is strong on the *how* and *why* of everything.

The workman's answer came right back, "Shut everything down and fixed it."

There is the secret of it! That man had been taught not only to think safety, but had been taught to act safety—to do what his common sense and good judgment told him to do.

Talk with any safety man and he will tell you that a company can pour money into its safety program, hire the best safety talent in the world, and work out all the foolproof contrivances possible to keep men from getting hurt, but unless the men are taught to look out for themselves to a certain extent, they are going to get hurt. Their every act must be an act of safety.

There was a certain ring of pride in that carpenter's voice. He was proud of the fact that he had done everything he could to throttle a beastly hazard that lurked in his shop. His good judgment said "fix it," and he fixed it, even though the fixing meant "shuttin' 'er down."

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He had put a rubber pad under a power saw, so that the rubber would check a slipping human hand from going into that buzzing and ripping bit of machinery that has no more respect for fingers and hands than it has for nature's most ordinary board.

With that start off, we proceeded to look at some records. And they surely do keep safety records at Armco: records that look you squarely in the face and tell you whether you are getting anywhere: records that help you to put your hand on any troublesome spot.

The most eloquent story of the safety program was told in the records of the Columbia Steel Company, Butler, Pa., and the Columbia Steel Company, Elyria, Ohio, which by purchase last August became a part of the American Rolling Mill Company's organization.

At that time the Butler plant employed 1,300 men. Sixty-five major accidents were recorded during the

first three months of 1927. But for the same corresponding period in 1928, under Armco's safety policies, there were only ten major accidents—a reduction of 84.6 per cent.

The record of Columbia mill at Butler for the entire year 1927 was 165 major accidents. Three months of that time was under the new management, which got under way with its safety program in October. Eleven major accidents went down on the record for that month, but November and December came through absolutely clear — not one major accident.

Let's step over to the Elyria plant. With 350 men employed, there were 31 major accidents in the first three months of 1927. Those same three months one year later under Armco's safety program are absolutely clear.

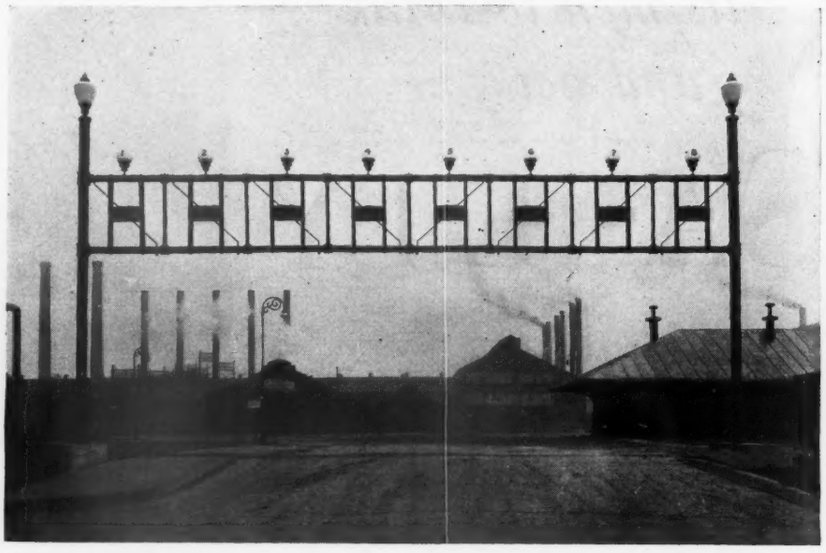
What can be the answer? The Butler and Elyria plants were the same, with the same superintendents, the same foremen, and the same men that they had before the change in ownership. But there was a different spirit under the new order of things—a management was in charge that for many years had been teaching men to think and act safety: a management that took safety as seriously as it took its business of making iron and steel sheets.

One of the first moves made after the acquisition of the Butler and Elyria mills was an analysis of those properties to see what could be done to minimize the hazards to workmen. The supervisor of safety made a typewritten report of 38 pages, recommending to the management just what should be done to prevent accidents. That report was passed up to the general management of the Columbia Steel Company with instructions to act on it at once. And the records cited are the result of that order.

* * * *

GUARDS LIKE THIS on the circular saws in the carpenter shop help to maintain a high safety record.

From the years of experience at the Middletown plant the management had learned that hazards can never be entirely overcome. They can be controlled, but they are with us always and ready to strike the moment the control is removed. In this respect, hazards are like caged tigers—harmless as long as the cage does its job, but leaping to take their toll of flesh and blood the instant the bars are down.



WHEN A GROUP has a major accident, out goes its light over the main entrance. The numbers under the lights show how many days the group has gone without having an accident.

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What, then, is the most effective control? The struggle to answer this question led to the formulation of the company's fundamental policy of safety, which is impressed and reimpressed upon the minds of every workman. It is simply this: "Any man who does not recognize accident prevention as one of the major problems of the operating executive need not expect to rise very high in the operating management of the company."

Having formulated a safety policy, the management enthusiastically accepts the responsibility of giving the key men in the different plants the management point of view at first hand. These key men, in turn, take the message down the line to every workman.

At least once a year George M. Verity, president, or C. R. Hook, general manager, visits each of the plants to talk safety at the biggest safety meeting of the year. Needless to say, with such active interest at the very top of the organization, every workman is profoundly impressed with the absolute seriousness of the company toward its safety program. These meetings serve to key up everybody, to make men more alert, and to accelerate safety thoughts.

The manager of each plant is responsible for carrying out the program within his own local plant organization. The plant manager, in turn, makes the superintendents and operating heads responsible for seeing that the program goes into effect among the workmen in every department. Thus, the channels through which the program is carried out radiate from the top down—never from the bottom up.

Every leader of men realizes that the highest operating record cannot possibly be obtained unless there is the very minimum of accidents. Teamwork makes production. If some member of the team is put out by an accident, the team is weakened and production sags. Consequently, the leader strives to avoid hazards within his group.

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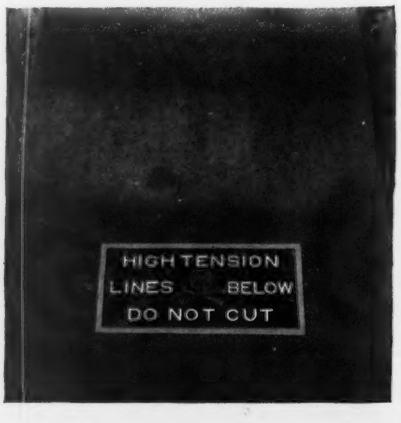
A STRIP OF RED CONCRETE and bronze plates mark the position of underground, high-tension lines.



Just what does the Armco safety department do? For one thing it is the headquarters from which is cleared the fund of safety information gathered from all the activities of the American Rolling Mill Company and national sources.

If, and when, an accident occurs at Middletown, information goes immediately to the plants at Ashland, Ky.; Columbus, Zanesville, and Elyria, Ohio; Butler, Pa., and the coal mines at Nellis, W. Va. Should the accident occur at one of these outlying units, a complete history of the case is sent to Middletown and immediately relayed to the other plants.

Headquarters must keep the banner of interest flying high. There must be something doing all the time; otherwise, things would soon get into a rut. So the safety supervisor and the local plant safety advisers are constantly studying out some new move. They stir up interdepartmental rivalry. They get one group to challenge another group, pit one plant against another, and end contests with rousing evenings of entertainment in which a big dinner is not the least appealing. However, losers of contests have to pay for the dinners of the victorious. That is all a part of the agreement, and the men look upon a free dinner as a badge of honor and distinction.

A COLLAPSIBLE GATE at the open hearth back standing is swung into position when men are working at the back of the furnace, to prevent anyone from falling into the pit.

* * * *

One of the best, if not the best, interest-arousing idea that ever came out of the safety department is represented by the safety trophy, a bronze statute of a steel worker typifying the spirit of safety. This handsome figure is shown at the head of this article. It is presented annually by the management to the plant having the best safety record. It stays at that plant until some other unit rolls up a better record.

The blooming and bar mill at the Ashland, Ky., plant was the first proud winner of the trophy. Then the blast furnace department of the same plant took possession of the prize the second year, but the Columbus blast furnace department wrested it away from Ashland this year. Now Ashland is saying, "We'll bring it home next year," while Zanesville is declaring that the reception for the bronze steel man is all ready in Zanesville. And so it goes in all the plants.

Each year the Middletown sheet mill department is divided into three turns and each turn strives to make the best safety record. At the end of the year, the losing turn gives a picnic for all the sheet mill men and their families. It is a gala day with good things to eat, inspiring addresses, athletic contests, ponies for the children to ride, merry-go-round, and dancing. This is the crowning event that is eagerly awaited.

What of it all? The records made at the Butler, Pa., and Elyria, Ohio, plants are enough to show anyone what can be done to save the worker the pain and suffering that go with broken and maimed bodies. Armco's program easily justifies itself on humanitarian grounds, but it is interesting to compare the safety record with the production record from a cold, business point of view.

For instance, the Columbus, Ohio, blast furnace plant with 280 men went through the entire year of 1927 without any man losing a day's work on account of injury. Central Works at Middletown went 186 days without a major accident. Most striking of all is the record of the electrical construction group, Middletown Works, which has not had a major accident in the past ten years. Other divisions made outstanding records, so that 1927 was the banner year in safety.

Considering production results to which safety work also contributed, 1927 saw the lowest cost of operation per single furnace in the company's history; record tonnage for month; record daily average for month; record tons of pig iron per day; record tonnage per furnace at Columbus blast furnaces; and lowest coke consumption ever reached in blast furnace operation. Production record after record was broken during 1927, when men were the freest from injury.

These results hold proportionately in all operations throughout the mills. Certainly here is convincing evidence that safety work is essential to the most efficient operation of a plant.

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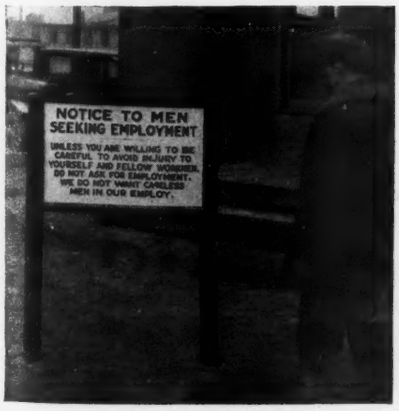
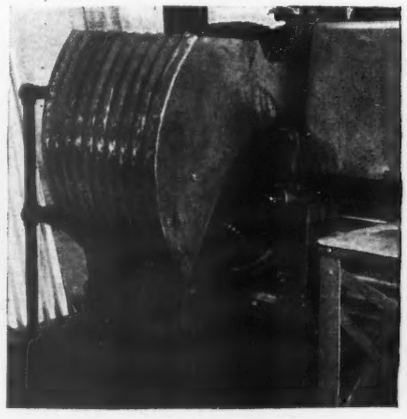
SIGNS SUCH AS THIS constantly remind the workmen that safety must be taken as a serious matter.


NOTICE TO MEN
SEEKING EMPLOYMENT
UNLESS YOU ARE WILLING TO BE
CAREFUL TO AVOID INJURY TO
YOURSELF AND FELLOW WORKMEN
DO NOT ASK FOR EMPLOYMENT.
WE DO NOT WANT CARELESS
MEN IN OUR EMPLOY.

WHEN OPEN GEARING is as thoroughly protected as it is here, there is not much chance of an accident happening.



INDUSTRIAL ENGINEERING
with which is consolidated
INDUSTRY ILLUSTRATED
Electrical, Mechanical and Plant Service in Industry
Published by the McGraw-Shaw Company

New York, June, 1928

Making Safeguards That Protect Men Also Protect the Machines

IN PRACTICALLY all safeguarding, stress is placed on the protection of the operators and anyone else who may come within a dangerous area. The life and bodily well-being of plant employees are, of course, of primary importance and so should receive first consideration in any safety program.

A point which is often overlooked, however, (considering only the guarding of machines or dangerous machine elements) is that a good safeguard for human protection may often be as valuable—only from purely monetary considerations—as the protection to the machine.

This is not so true in connection with the design and installation of safeguards for machines or mechanical transmission, however. For example, an exposed rotating part with projecting lugs, as on some clutches, open gears, or other unprotected but breakable parts, are dangerous to those who work around them. Likewise, these parts are exposed to such hazards as, falling or carelessly handled materials, the wrench or other tool that slips (in such a case the machine may get both the tool and the man), and often foolhardy or malicious mischief. Frequently a slight change or addition to the guard would be necessary to keep the proverbial, and often literal, "monkey wrench out of the machinery." More attention could well be given to machine protection and generally, the results would provide greater safety to the human element.

An Ideal and An Epitaph

COMMENTING on the recent death of an old employee, the president of one of our great corporations summed up the record of an unusually active and fruitful life in the words, "Creator and developer, he left better whatever passed through his hands."

To only a few is it given to attain fame through the development of revolutionary processes or ideas. In the nature of things, it must be the lot of most of us to find our work and success in improving the mechanisms and systems that represent the life work of the many who have preceded us. Nevertheless, the wish to leave better whatever passes through our hands will tax the mind and energies of any man.

Many, probably most, successful careers are founded on the ability to focus enough study and ingenuity on the job in hand to reveal the weaknesses and defects, and the remedy for them. Men who have the ability and will take the pains to do this almost inevitably pass from one task to another which involves still greater responsibility and opportunity.

Every man who is concerned with plant operation has countless opportunities to make his mark. Only an almost inconceivable lack of knowledge and vision could enable one to say that industrial equipment, methods and processes have reached perfection. In many ways we are only at the beginning of a new era that will show many of our present practices to be woefully inefficient.

Great as the advances will be, they will for the most part be made, not by men who are elemental geniuses, but by ordinary mortals who have an overwhelming desire to leave better everything that passes through their hands.

Dig Down Behind the Averages

TOO many of us have formed the habit of thinking in "averages." We sum up the performance of the past week, or month, or year, and find that it averages so-and-so. And that is the mark we shoot at for the next week, or month, or year.

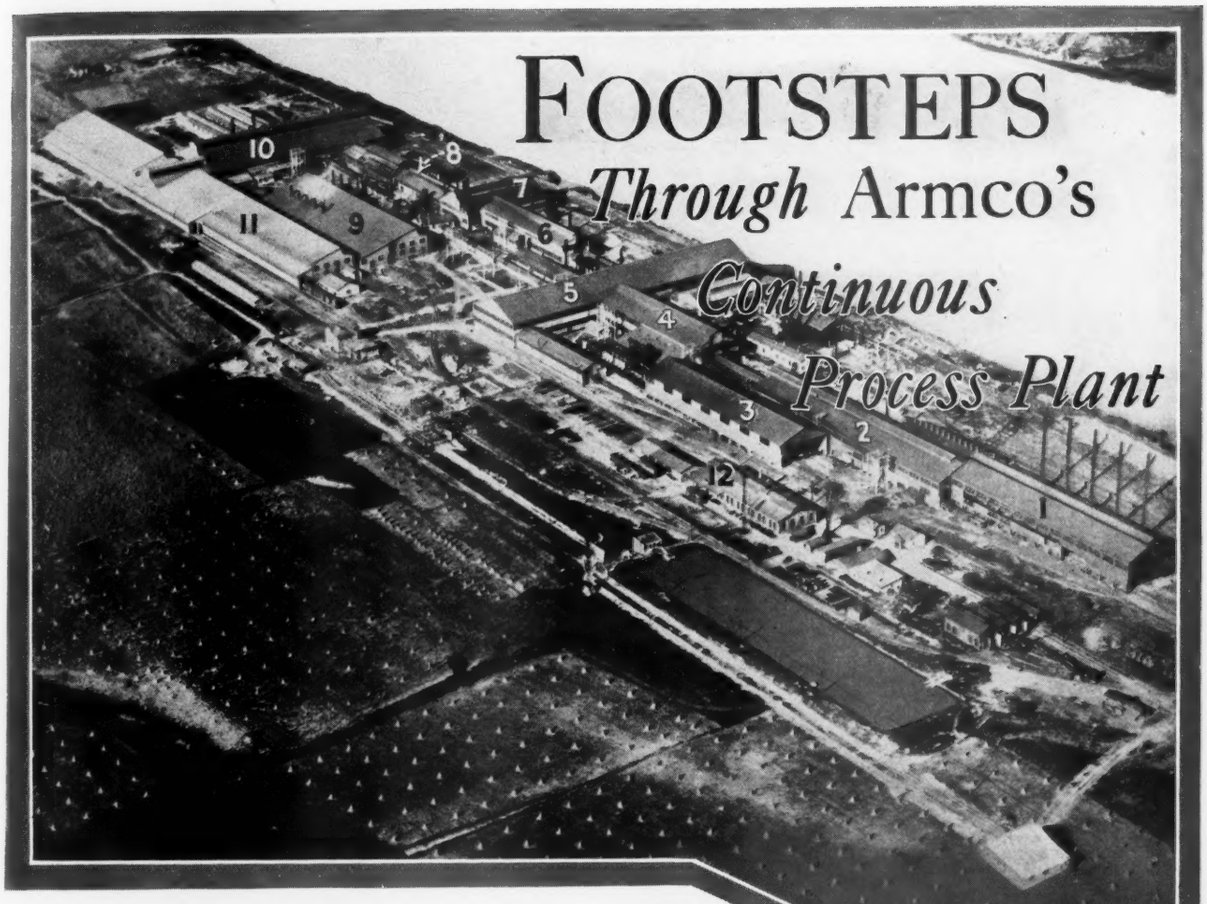
Then we wonder why progress is so slow; why we, individually, get ahead no faster, and why this department or that is lagging behind.

If you averaged two lost-time accidents per month, for the past twelve months, forget that figure; what was the *best* month? That—and not the average—is the mark to shoot at for the next twelve months. The best figure, buried within the average, is the one to aim at; the worst figure is the one to study, to find out why, to forestall repeating it.

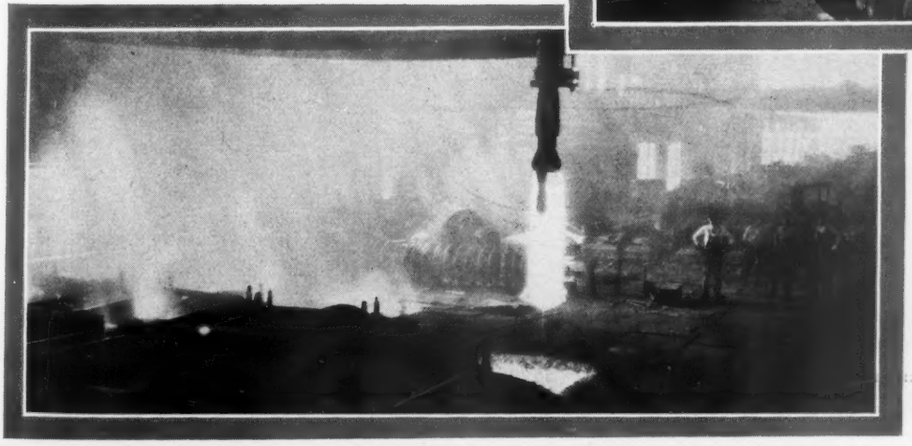
If your repair shop had twenty jobs to turn out last month and fell down on only two of them, it averaged 90 per cent for the month; not bad—unless you, and your machine shop foreman are content to agree that it is not bad. If you let it go at that, so will he; and the next time, when you find that the average is only 75 per cent efficiency, he'll be only human if he says, "Well, we came pretty close, anyhow." Close to what? Close to the average.

Dig down behind the averages. Get at the details and the reasons behind them. The only important thing about a 90 per cent record in any department under your jurisdiction, is the 10 per cent failure.

FOOTSTEPS *Through* Armco's *Continuous Process Plant*

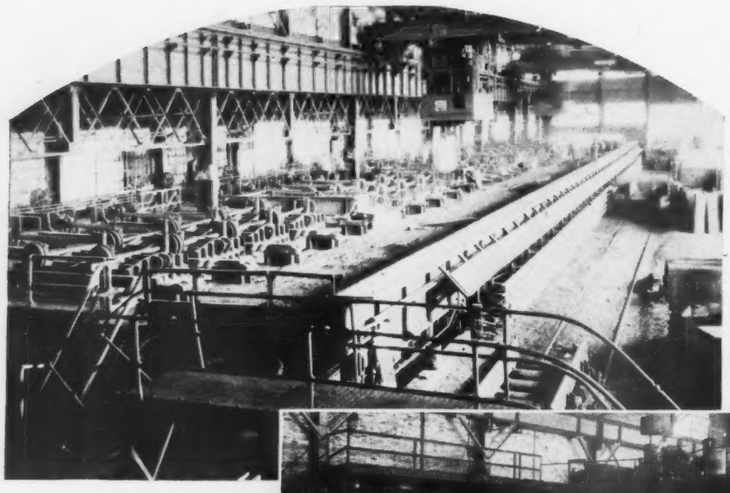


An airplane view of the Ashland, Ky., plant of The American Rolling Mill Company. The various buildings may be identified as follows, giving a clearer idea of the layout of operations: (1) The building housing the Soaking Pits; (2) Blooming Mill and Bar Plate Mill; (3) Bar Plate Storage building; (4) The Jobbing Mill; (5) Jobbing Mill Warehouse; (6) Sheet Rolling Mill; (7) Sheet Mill Shear building; (8) Continuous Sheet Annealing and Pickling; (9) Galvanizing department; (10) Cold Roll and Box Annealing department; (11) Warehouse; (12) Stores building.



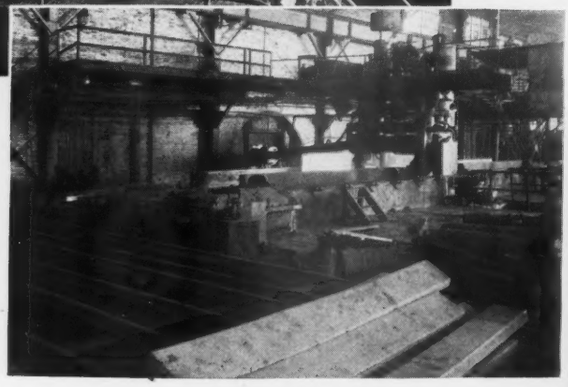
Pouring metal into the ingot molds. The men on the pouring platform are protected by special clothing. The molds are mounted on trucks, and after pouring, the mold train is shifted into the soaking pit building.

Taking an ingot out of the soaking pit. There are five four-hole pits, heated by coke oven or natural gas. Ingots are removed in response to signal whistle from the blooming mill.



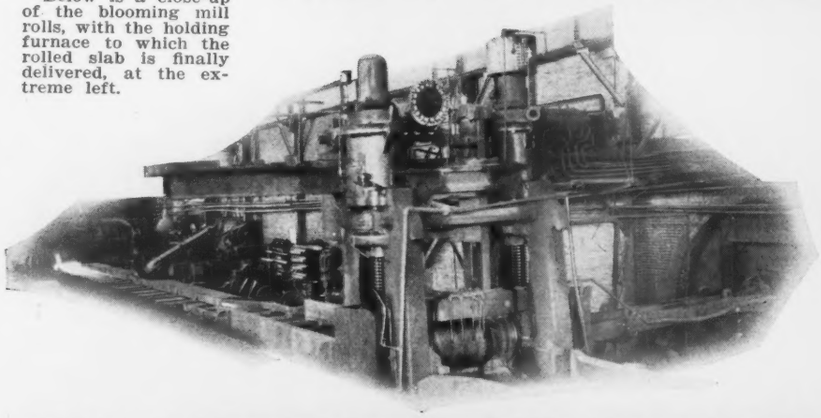
At the left, a view of the soaking pits. The building housing them joins the blooming mill building, and this view is taken from the latter end. Note the ingot chariot and tracks at the right, for delivering ingots to blooming mill table.

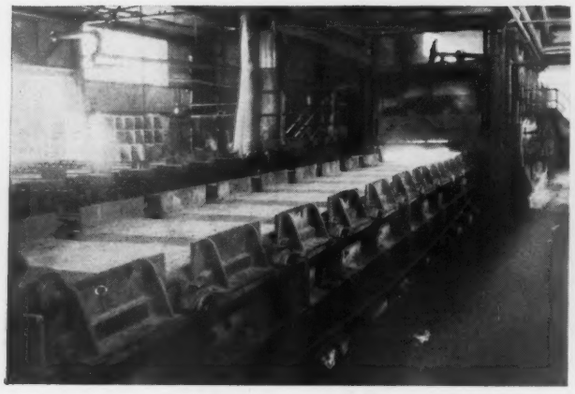
The blooming mill rolls the ingots out, after successive passes through the rolls, to a slab four inches thick by 36 inches wide and about 23 feet long.



Slabs from the holding furnace are sheared, as they emerge, into short lengths which are then delivered crosswise, by means of skew rolls, to the bar plate mill.

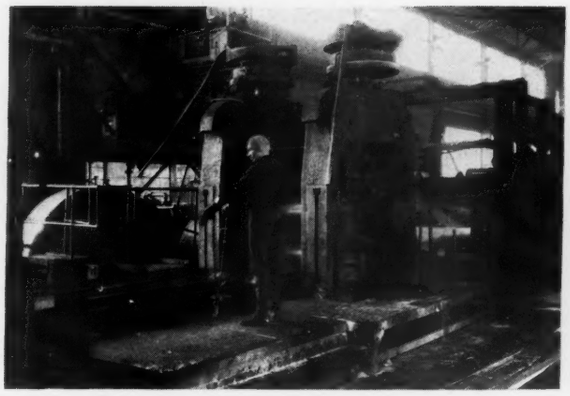
Below is a close-up of the blooming mill rolls, with the holding furnace to which the rolled slab is finally delivered, at the extreme left.



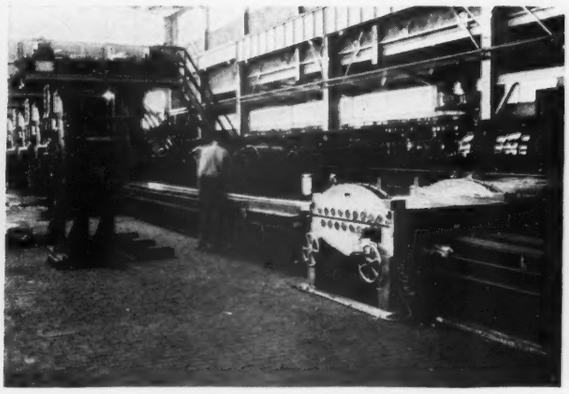


Section of table between bar mill and jobbing mill holding furnace.

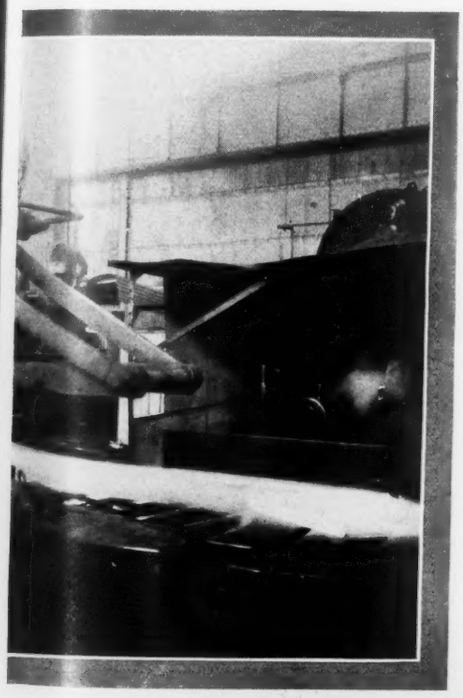
Rolling bars across the grain on the continuous bar mill.



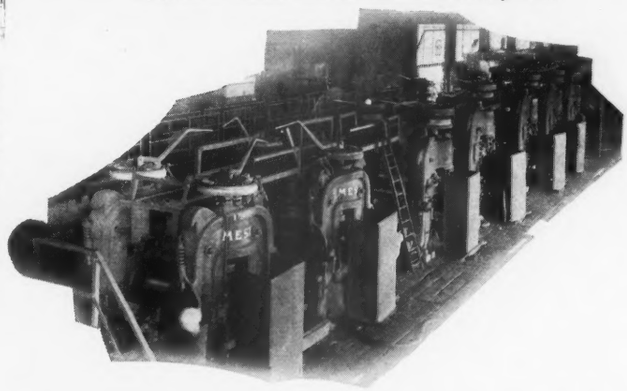
Sheets pass in a continuous stream through such stands of rolls which reduce the metal to thinner gage.



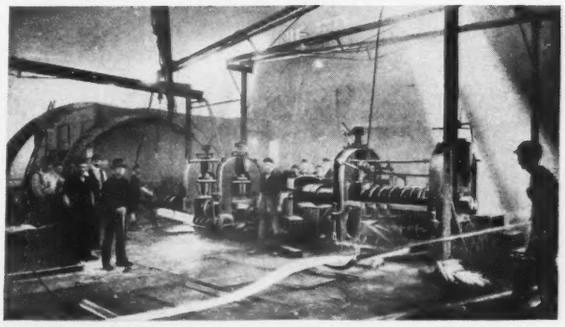
Roller leveller on No. 2 sheet mill. This operation makes the sheet commercially flat.



7-Stand jobbing mill which produces sheets up to 16 gage, 44 inches wide and 140 inches long. The last four stands are equipped with 3-high rolls, reductions being effected only by the bottom and middle rolls. Stock can be delivered by the last stand at 666 feet a minute.

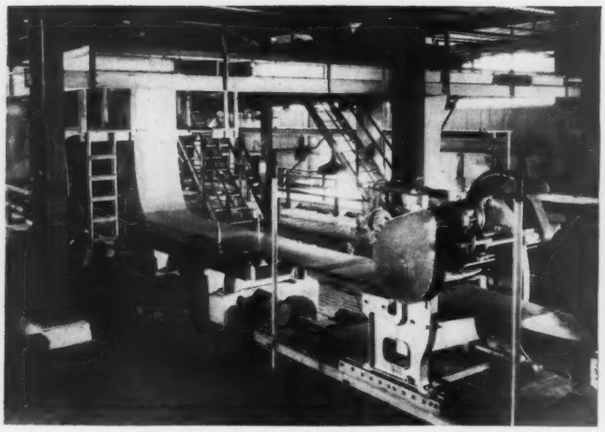


Scenes showing rolling of sheet bars by crude hand methods in the Armco plant twenty-five years ago, when it consisted of one 25 ton open hearth furnace and less than 300 employees.



The customary method has been to heat bars in the pair furnace for individual rolling.

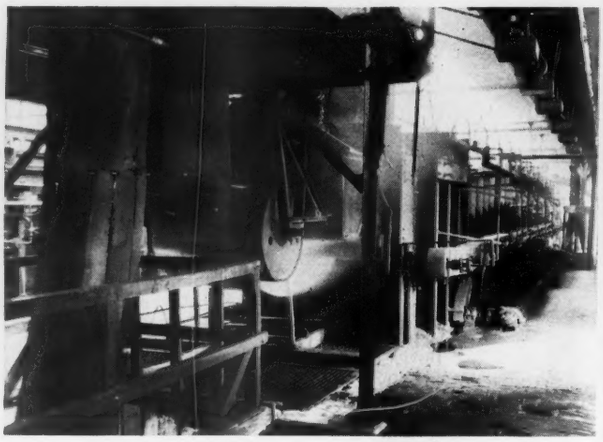
Sheet mills had always been side by side, with individual operating crews.



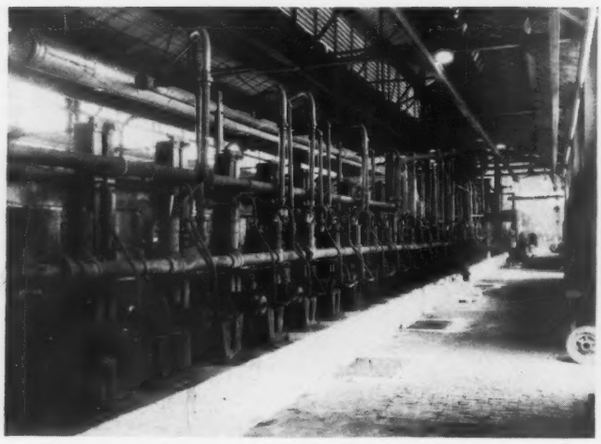
Tandem shears which eliminate the stitched portion and permit the sheets to be handled separately through the cycle of finishing operations. The distance between shears may be regulated to permit cutting different lengths.

Sheets piled for annealing. The boxes are placed over the sheets and sealed. They are then put in furnaces for heat treatment. This process is on a continuous basis in handling boxes in and out of the box annealing furnaces.

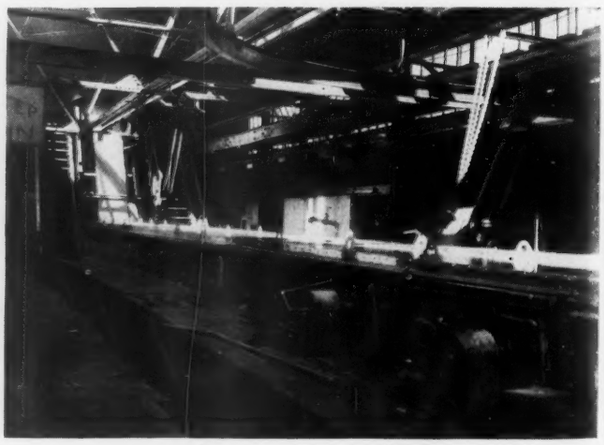
The old hand method. A "catcher" returning sheets over the rolls. In the continuous process, mechanization has replaced the catcher.



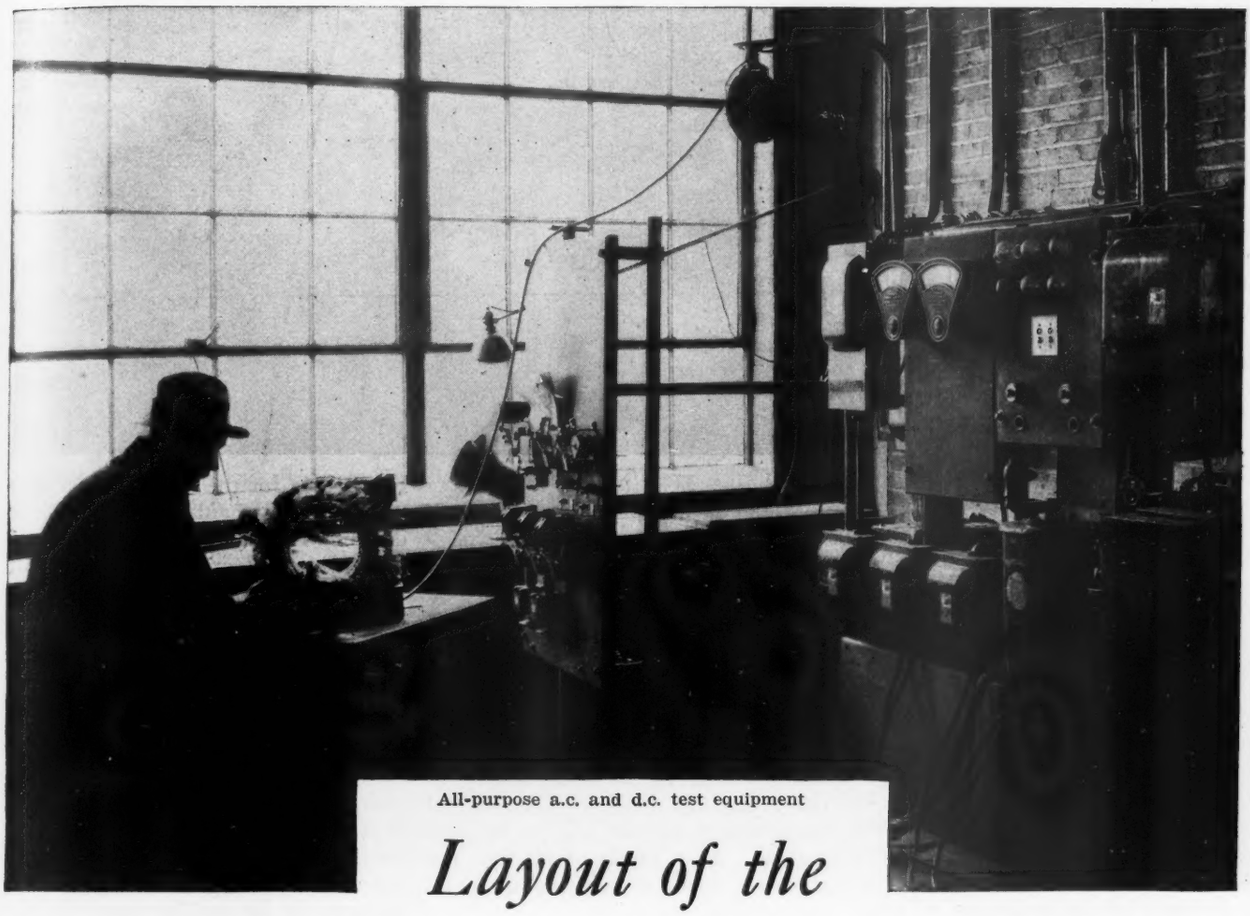
Ribbon of sheets entering continuous annealing furnace. Loops shown at left, permit stitching without interrupting the travel.



Continuous heating furnace in which rough plates in packs of two are heated preparatory to being rolled to lighter gages on the continuous sheet mill.



A long ribbon of sheets passes from the continuous annealing furnace to the pickling tank, where the surface of the metal is thoroughly cleansed in acid water.



All-purpose a.c. and d.c. test equipment

Layout of the Electrical Repair Shop

and its methods of servicing continuous process equipment

By W. A. BECK
Managing Editor
Industrial Engineering

IN THE iron and steel industry of this country, the electric motor has rapidly supplanted the steam engine and the hydraulic cylinder, which were the two most commonly known sources of power in use. Among the principal reasons advanced for the increased application of electrical energy by this leader in industry with its total connected load of 5,000,000 hp. or more, is the ease with which a motor can be applied directly or indirectly to its drive, together with the facilities to control it from remote points. It is this flexibility that makes the application all the more desirable for the continuous production process developed by the American Rolling Mill Company of Middletown, Ohio, for the manufacture of ARMCO ingot iron sheets.

However, the motors and control equipment in use today are not without fault. They too, have inherent limitations in common with other production machinery and when these limitations are exceeded, the equipment usually breaks down, necessitating either quick repairs or replacement and ultimately repair shop attention.

Every plant has its own problems of maintenance responsibilities whether the production process is continuous, semi-continuous or otherwise, but it is well to learn from industrial leaders just how they are set up to handle theirs. Consequently, it is the purpose of this article to deal with the electrical repair shop practices and the facilities provided in the general maintenance scheme in the first plant of its kind engaged in the manufacture of iron sheets on a continuous basis. How the electrical equipment in the plant is serviced under normal operating conditions is covered in another article in this issue, but how this equipment when in need of extensive repairs is handled in getting the necessary repair shop attention will be described briefly before taking up the repair shop practice in detail.

At the Ashland, Ky., plant of the

American Rolling Mill Company where this continuous process has been established, the responsibility for quick repairs and replacement of electrical equipment in the plant rests entirely upon the section foremen of the electrical maintenance department. If an emergency occurs that might interfere with the continuous process, good judgment must be used in deciding, after diagnosing the trouble, whether quick repairs shall be made by the electrician, or if the equipment shall be replaced.

Assuming then for the moment that the latter decision is carried out, a spare unit goes into service. To the defective piece of apparatus is attached a shop order tag upon which is noted date, shop order number, material classification and the extent of the repairs desired, where it is to be delivered to when repaired and the signature of the electrical maintenance foreman. This tag insures the delivery of the equipment to the electrical repair shop, where it will be placed in first-class condition and returned within the time specified on the shop order that is forwarded by inter-department mail, and which authorizes the electrical repair shop foreman to proceed with the work.

Because of the continuity of plant operation and the desire to keep the investment in spare equipment as low as possible, it was imperative that the electrical repair shop that was provided to carry on repair work must be well equipped with men and machinery, if it was to accomplish its purpose. Moreover, the ability to make the necessary repairs quickly and economically was the yardstick

INTERIOR VIEW of the electrical repair shop where ample space is provided for the convenience of the repairmen. All bench work and machine work is done on opposite sides of the center bay, which is used principally for storage and transportation.

* * * *

by which its activities were to be measured in servicing the 2,500 motors (42,000 hp.) in the plant.

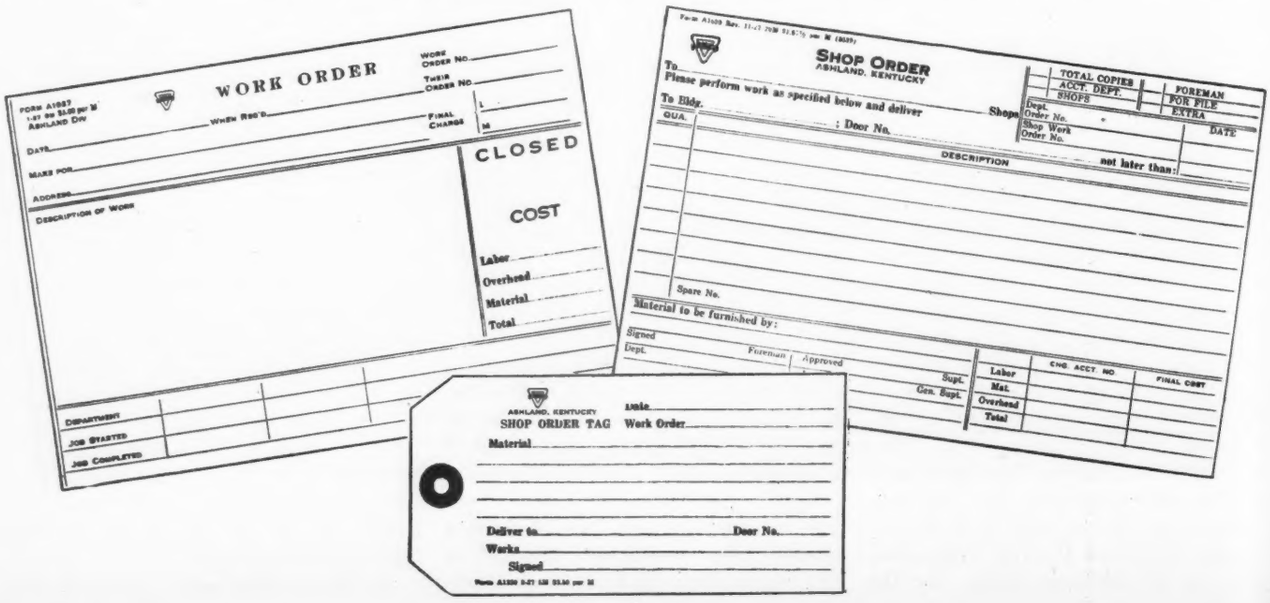
The personnel of the electrical repair shop must also meet certain qualifications as to their ability to carry on the work if the general maintenance scheme was to be successful. As a result of all this, the electrical repair shop, therefore, is an independent unit.

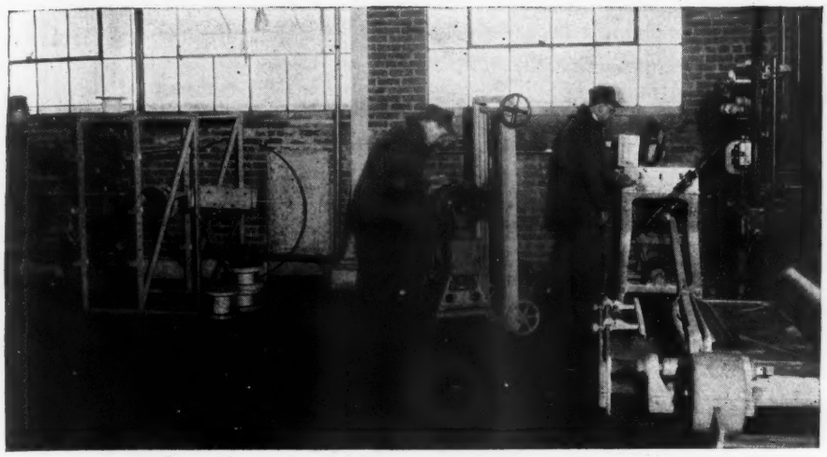
The personnel chart shown in an accompanying illustration will make clear the organization set-up that is

* * * *

THE SHOP ORDER Form *A*1020 at the right and the Shop Order Tag at the bottom accompany all equipment sent to the shop for repairs and from which the Work Order Form *A*1027 is made out by the shop foreman. Accurate repair cost data are obtained if this order bears "accrue cost" stamped on its face.

responsible for the class of work that is done. All regular repair work is done in the daytime by a force of fifteen men under the supervision of a foreman who reports directly to the superintendent of electrical maintenance and each man is classified in accordance with his ability to perform certain work. For instance, the recorder handles the clerical work such as filling out cost sheets, office records, etc. The tool keeper is in charge of the tool room in which are kept all winding supplies including the portable test instruments that are used by the general maintenance department in making tests on the electrical equipment in the plant. One lathe hand does all machine work required. Two motor repair men, one Class *A*, the other Class *B*, do all general motor repair work. Three armature winders, one Class *A*, one Class *B* and one Class *C* repair and rewind armatures only. One man takes care of controller and control repairs in addition to building up new control





TENSION WITHOUT insulation damage for coils made on the Browning loop-winder is obtained by weaving the wire over eight brass rolls built in the reel rack. The home-made growler is shown in action in the center of the illustration.

* * * *

panels, similar to one shown in front of the main test board in the illustration. Telephone repairs are handled by one man exclusively. Two shop helpers, one Class *A* and one Class *B* assist in all shop work, where they get an opportunity to learn what the other fellow is doing. One man is employed to drive the shop truck which is used to transfer the electrical equipment between the mills and the repair shop. This organization must be maintained as shown on the chart, for no changes are permitted unless authorized by the management.

* * * *

SCHEMATIC ORGANIZATION layout showing entire repair shop personnel according to duties and class of worker. Note that armature winders are designated by class *A*, *B*, or *C*.

The shop is centrally situated with respect to the entire plant and located in a single story brick and steel building, about 75 ft. wide and 200 ft. in length, half of which is devoted to a pipe shop and rigger's shop for the maintenance department. Good lighting is obtained from almost full-length windows in the south, east and north walls and in the roof section. Those in the roof-section may be adjusted from the floor to provide the necessary summer-time ventilation. Winter-time heating is furnished by radiators installed on the side walls and two Buckeye unit-heaters driven by 1-hp. motors suspended about 12 ft. above the floor level on opposite sides of the center aisle, in about the middle of the shop. Offices for the repair shop foreman and the general foreman of electrical maintenance take up opposite corners in the west end of the building.

Along the north side of the shop just off the center aisle, is the power driven machinery which consists of the following equipment:

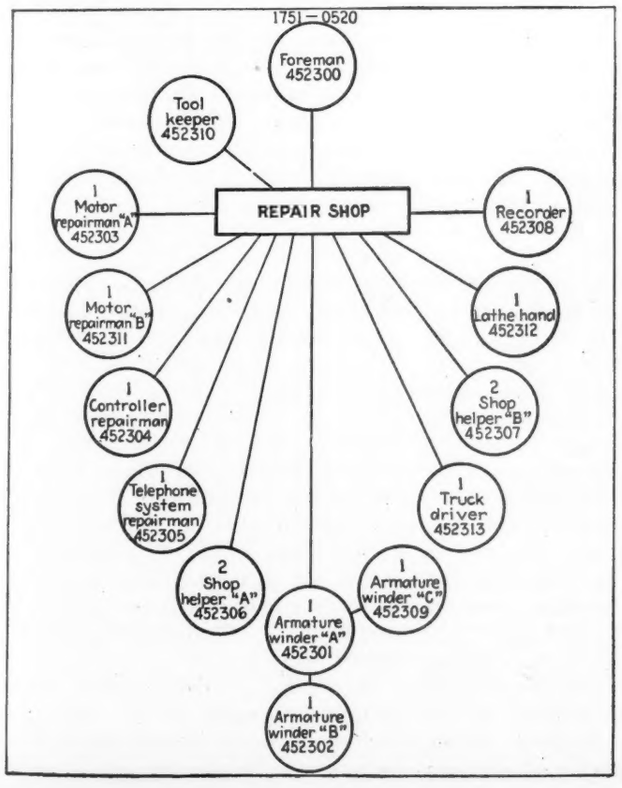
1 27-in. LeBlond heavy-duty lathe.
1 16-in. Strong & Hammond lathe.
1 24-in. Cincinnati drill press.
1 Webster & Perkins grinder.
1 30-ton Naperville Tool Company perfection press.
1 21-in. American Tool Works Company shaper, and
1 Racine power saw.

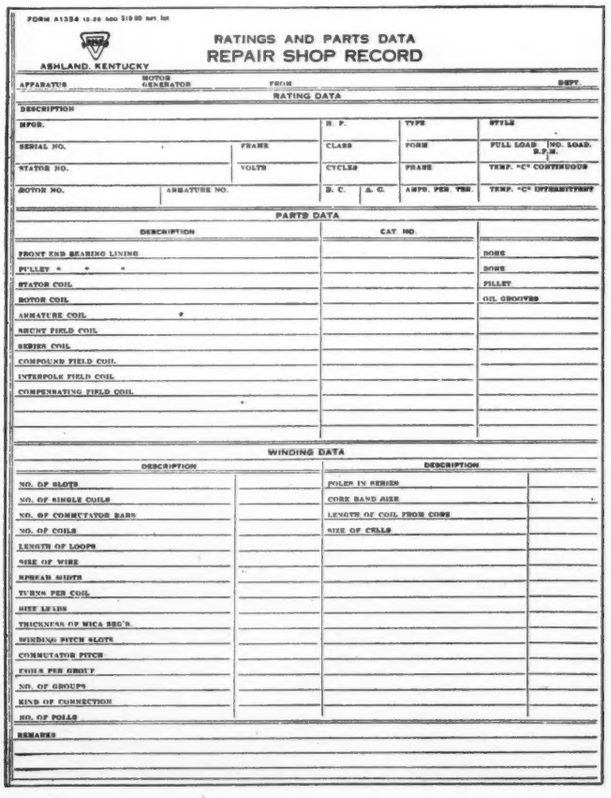
All the above are driven through overhead line shafting by a 15-hp. 440-volt 1,800-r.p.m. G.E. motor mounted overhead but controlled from the floor, by means of a G.E. drum-type controller.

Adjacent to the general foreman's office on the north side is the main test board where all equipment is brought for intermediate and final testing before being returned to the mill.

* * * *

RATING AND PARTS Data Forms constitute a valuable part of the shop records. All equipment passing through the shop for the first time is described on this form in detail.





RATINGS AND PARTS DATA
REPAIR SHOP RECORD

ASHLAND, KENTUCKY

APPARATUS MOTOR GENERATOR FROM DEPT.

RATING DATA

DESCRIPTION
MFGR. H. P. TYPE STYLE
SERIAL NO. FRAME CLASS FORM FULL LOAD R.P.M. NO. LOAD R.P.M.
STATOR NO. VOLTS CYCLES PHASE TEMP. °C° CONTINUOUS
ROTOR NO. ARMATURE NO. D. C. A. C. AMPS. PER TER. TEMP. °C° INTERMITTENT

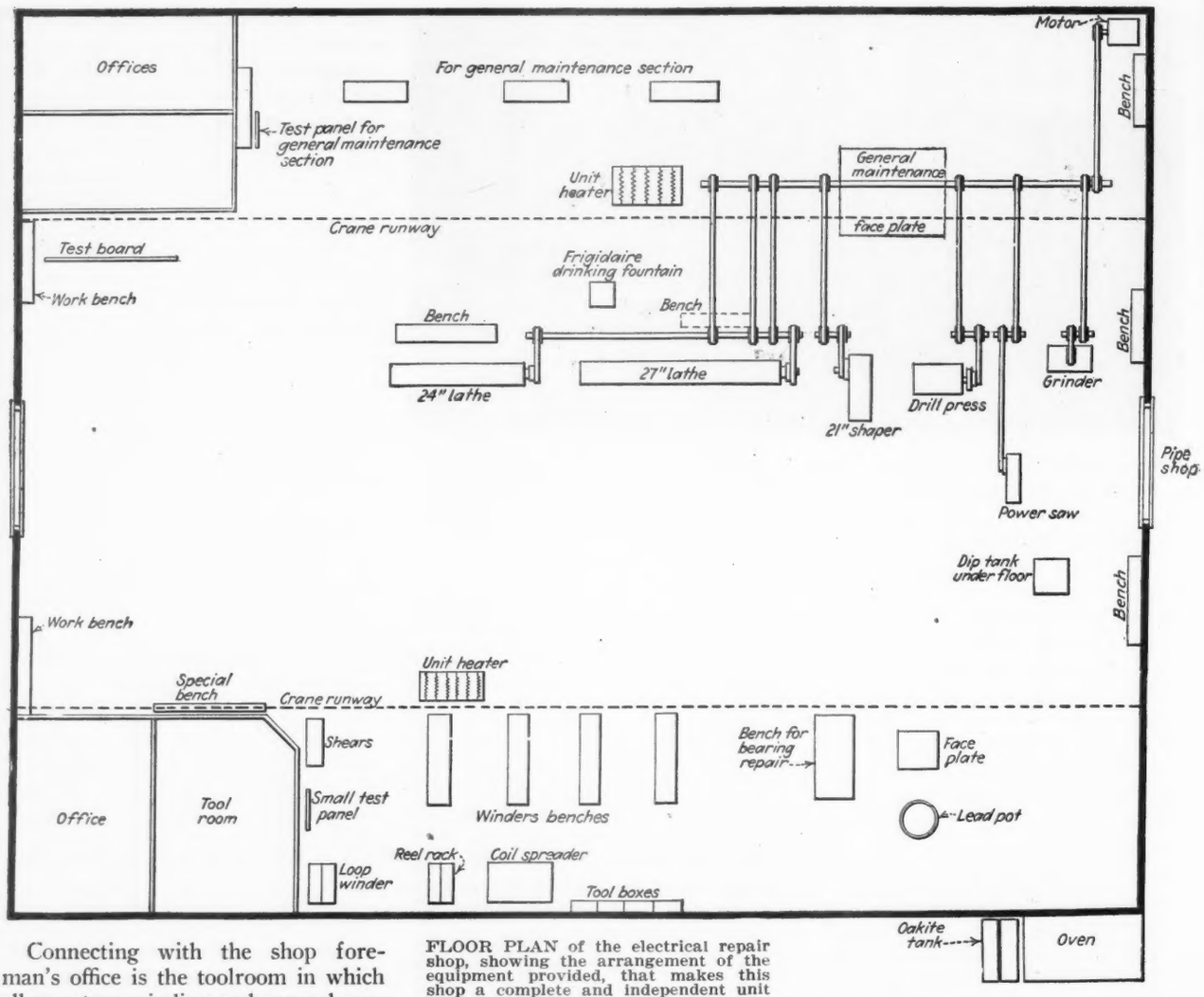
PARTS DATA

DESCRIPTION	CAT. NO.	
FRONT END BEARING LINING		BORE
PULLEY " " "		BORE
STATOR COIL		FILLET
ROTOR COIL		OIL GROOVES
ARMATURE COIL		
SHUNT FIELD COIL		
SERIES COIL		
COMPOUND FIELD COIL		
INTERPOLE FIELD COIL		
COMPENSATING FIELD COIL		

WINDING DATA

DESCRIPTION		DESCRIPTION	
NO. OF SLOTS		POLES IN SERIES	
NO. OF SINGLE COILS		CORE BAND SIZE	
NO. OF COMMUTATOR BARS		LENGTH OF COIL FROM CORE	
NO. OF COILS		SIZE OF CELLS	
LENGTH OF LOOPS			
SIZE OF WIRE			
SPREAD WIDTH			
TURNS PER COIL			
SIZE LEADS			
THICKNESS OF MICA SEG'S.			
WINDING PITCH SLOTS			
COMMUTATOR PITCH			
COILS PER GROUP			
NO. OF GROUPS			
KIND OF CONNECTION			
NO. OF POLES			

REMARKS



FLOOR PLAN of the electrical repair shop, showing the arrangement of the equipment provided, that makes this shop a complete and independent unit of the entire plant.

* * * *

Connecting with the shop foreman's office is the toolroom in which all armature winding and general supplies are kept in steel bins until needed, including such portable metering instruments as are used by the maintenance group. Just outside the toolroom is a special work bench equipped with a small lathe for winding solenoid coils, a Segur taping machine, a small armature winding machine and a cell former.

The lathe and the coil-taper are bolted to the bench and both are driven from a 1-hp. 440-volt type CSA a.c. motor through an intermediate shaft suspended beneath the bench. Power is applied to either the lathe or the taper by means of a Segur power transmitter which is actuated by foot-pressure, thereby permitting the hands to be free. A counter attached to the lathe registers the number of turns of wire wound on any core, thus relieving the operator of this monotonous detail especially when large coils are to be wound with fine wire. The small armature winding machine is hand operated but it is used only for fractional-size motors.

The cell former should be of interest to other repair shop employees, inasmuch as they perhaps have desired to know where such equipment could be purchased. Strange to say, that up to a short time ago a machine to do this work as far as the market was concerned was neither fact nor fiction. Most repair shops either built their own contraption or else the cell slots were made by hand. Cell slots, however, up to 8 in. in length can be made just as quickly as the operator can work his arms. The cell former is no more than a light press with changeable dies to correspond to the cell size desired. The paper or insulating material is placed on the stationary portion of the die and in bringing the upper and lower die sections together with ordinary pressure the cell slot is ready for use.

The space on the south side between the tool room and the west end of the building is occupied by the armature winders' benches, insulation shears, coil winder, loop spreader, reel rack, growler and auxiliary test panel. The 8 x 8 x 10-ft. oven which is built in the southeast corner although flush with the inside of the shop is heated by means of 24 Hold-heat 220-volt units arranged in six shallow depressions in the walls near the floor. The temperature is maintained at about 85 deg. C and controlled by four inclosed Trumbull safety switches conveniently mounted to the right of the oven on the wall. Service is taken from the 440-volt a.c. shop circuit, and fed to the units which are connected in series across the line. Each switch controls six units, as follows: the lowest units of two stacks are connected in series, as are similar units in the other four racks; these units, so connected in series, are then connected across the 440-volt circuit that is controlled by one switch. All other units are connected likewise.

A 500-lb. gas-fired babbitt pot is installed adjacent to the oven for melting down the Promet that is used in renewing bearing linings.

A dip tank measuring 4 x 4 x 4 ft. is located beneath the floor in the center aisle where equipment to be dipped can be handled by the crane. A 6-in. pipe is welded in the center of the tank on the bottom so the shaft will extend through when dipping an armature. The armature remains in the paint until all air bubbles cease, and then it is lifted out by the crane and allowed to drip.

All heavy work brought to the shop is handled by a 5-ton capacity Reading crane that travels the entire length of the shop. This crane is equipped with motors on the trolley, hoist and bridge, and controlled from the floor by self-centering controls suspended from the trolley. No vivid imagination is needed to compare the facilities provided to service the continuous process production machinery with the former repair shop in which no power driven machinery was installed. Where the oven consisted of a dry goods box heated with Cutler-Hammer resistance units, and the dip tank was a 5-gal. can so that with the aid of an ordinary water dipper the paint could be applied to the parts to be treated. No doubt, many electrical repair shops came into existence in this same manner, but few stand out as examples of what an up-to-date repair shop should be like.

In the east side of the building is a double door that opens onto the driveway to permit the service truck to enter with the equipment that is to be repaired, and which bears the tag mentioned heretofore. This equipment is identified by the shop order Form 1020 which has been received in the mail so preparations are made to repair it in accordance with the instructions. The shipping tag, however, remains with the equipment all the time that it is under repairs, being renewed when the equipment is to be returned since by this time it has become badly soiled due to handling.

* * * *

Ordinarily, shop orders do not carry an accurate cost record of the work done, but if an accurate cost of the repair work is required, the foreman stamps "accrue cost" on the face of the original shop order as shown.

To obtain the accrued cost of any repair job, the foreman transfers the data from the shop order Form A 1020 to an electrical repair shop accrue cost work order Form A 1027, upon which will be noted all costs entered against the repair job. For instance, all control repair work is not conducted on a cost basis, but all motor and armature repair costs are collected and kept as a matter of record. The reason for this is obvious. If the equipment record which is maintained in the electrical superintendent's office shows that a piece of apparatus requires extensive repair work to keep it in service an investigation is made to determine the cause of these successive failures. First, by determining if the repair shop work is faulty, or secondly, by running a test on the equiment it serves, to see if the particular apparatus has sufficient capacity to meet the demands of the service to which it is subjected. These tests are made by the testman, assisted by a helper, using Esterline portable graphic instruments wherever possible in order to get a permanent record of the test.

If the results of the test show that the equipment is overloaded, it is replaced and the spares department is notified of the change, since it is their responsibility to keep sufficient spares on hand. Very seldom is the cause reflected to the repair shop for during the past year 262 armatures were either repaired or rewound, none of which came back, except in the case of induction motors, for bearing renewals.

The vigilance practiced is no doubt responsible for the enviable record in this shop. However, after it is known whether accurate costs are to be kept, the equipment so received is turned over to the repairmen who specialize in the repair work required. If it happens to be a motor they begin at once to fill out the motor and armature inspection report from the information they obtain in making a thorough preliminary examination which includes certain standard tests. This procedure insures good work in the final analysis, for nothing escapes their attention.

Knowing, then, the extent and nature of the repairs, plans are made to accomplish them within the delivery date specified by the maintenance foreman on his shop order. If it is a rewind job the motor is torn down. The bearings are removed and the stator coil ends are cut off flush with the slots, but no attempt is made to drive out the remaining wiring in the slots. Damaged laminations, as a result of proceeding in this manner has taught them how to do it differently.

The stator or armature is taken to the cleaning tank, which is located outside the shop but adjacent to the protruding baking oven, where it is submerged in a heated solution of Oakite for an hour or more, depending on the size and the condition of the winding. This bath removes dirt, grease, paint and as much insulation as possible so that it is very easy to remove the winding remaining in the slots without injuring the laminations. In addition, the job is clean and in this shape it is easier to handle.

(*Please turn to page 310*)

* * * *

MOTOR AND ARMATURE Inspection Report Forms like this are filled out by the repairmen who inspect and test the equipment as soon as it is received. By this method defects are revealed rather than concealed.

Form A1342 6-27 1M 26.75 per M

MOTOR AND ARMATURE INSPECTION REPORT

WORK ORDER_____ DATE_____

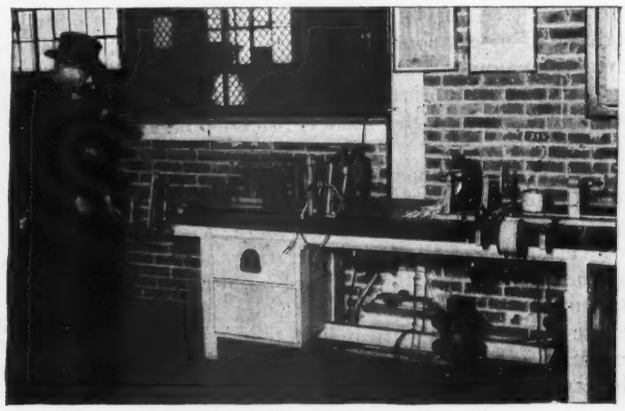
DESCRIPTION		FROM			DEPT.
H.P.		H.P.	TYPE	STYLE	
SERIAL NO.	FRAME	CLASS	FORM	FULL LOAD / NO LOAD RPM	
STATOR NO.	VOLTS	CYCLES	PHASE	TEMP. "C" CONTINUOUS	
ROTOR NO.	ARMATURE	D.C. / A.C.	AMPS. PER TER.	TEMP. "C" INTERMITTENT	
INSULATION	COMMUTATOR	FIELD COILS		BRUSHES	
BEARINGS	SHAFT	CLEARANCE		ARMATURE COILS	
GROUNDED	SHORTED	OPEN			

REPAIRS NECESSARY:

C. C. FOREMAN O. K. SHOP FOREMAN

REMARKS:

SIGNED



A SPECIAL BENCH equipped for a variety of purposes expedites repairs on small work. In addition to winding solenoid coils, small armatures, and taping coils, slot cells are made on the cell former that was built here.

Lubricating one of the shears, at the American Rolling Mill Company

Modern Lubrication Practice *In the Steel Mill*

By ALLEN F. BREWER
Mechanical Engineer
The Texas Company
New York, N. Y.

PRACTICE in lubrication of steel mill equipment has undergone a decided change during the past few years. There has been marked trend towards adoption of automatic means of applying lubricants in the interest of elimination of hazard to operators; reduction in power consumption and friction, and assurance of more positive machine operation. In fact it may be safely stated that modern methods of intensive production are largely contingent upon effective lubrication as it has been developed in the modern steel mill.

The problem of getting the maximum results from lubrication has not been an easy one to solve, for there are certain conditions of operating pertinent to the handling of steel mill equipment which involve decidedly severe duty. Comparatively high temperatures adjacent to much of the machinery, and bearing and gear tooth pressures considerably above normal, have been the salient factors encountered. Both require the utmost care in selection of lubricating oils, greases and gear compounds which will function effectively, and means of lubrication which will assure delivery of such products in positive, sufficient and yet economical amounts.

High temperatures as will be encountered, for example, adjacent to the open hearth, soaking pits or rolling mills may bring about any one of three occurrences, viz.: reduction in viscosity or body of a lubricant, the development of carbon deposits and the possibility of fire and personal hazard if the flash point is exceeded.

Reduction in viscosity or the rendering of a lubricant so fluid as to be unable to maintain a protective film of sufficient thickness between the wearing parts may be decidedly serious in that it may give rise to solid friction, abnormal wear, the possibility of inaccurate rolling, for example, and the necessity for ultimate renewal of bearings, gears or shafting.

A typical instance of where this may be experienced in certain cases is on the bearings of hot metal mixer fans, as well as on open hearth charging machines.

It will be of interest to note that viscosity is that characteristic which is indicative of the relative degree of fluidity of oils, gear lubricants and light greases. Usual practice in the purchasing of such products is to quote viscosity requirements at a standard temperature of test such as 100 or 210 deg. F. In view of the fact, however, that the viscosity or relative fluidity of an oil will vary inversely with the temperature, knowl-

edge of the "operating viscosity" at the probable temperature at which such a lubricant may have to function, will be decidedly advantageous.

Normally experience will have been gained as to approximately how heavy an oil should be to give best results. This experience, coupled with a suitable temperature - viscosity chart whereon the viscosity at any particular temperature can be noted, will be of considerable value when selecting new lubricants, or when carrying out tests on new installations or types of lubricating equipment. Take for example, a gravity circulating system as applied to the speed reduction drive of a plate or sheet mill. Here should experience have indicated that the oil should have an operating viscosity of about 250 seconds Saybolt at say 160 deg. F. (the temperature at the bearings) the data to use when in the market for new lubricants should be approximately 1400 to 1450 seconds Saybolt at 100 deg. F. or about 100 seconds at 210 deg.

While it is of course, essential to be careful to obtain an oil which will have adequate body at the maximum temperatures of operation, it must be borne in mind that these latter may not prevail throughout all parts which the intended product must lubricate. Were there to be a decided variation in temperature, the oil at certain bearings and gears might be entirely too sluggish to function with a minimum of power consumption. The resultant drag might in fact be quite as serious as the possibility of abnormal wear of parts exposed to higher temperatures, especially from the viewpoint of operating costs and speed of production. Such a condition should be studied carefully, and if necessary, oils of varying body tested to arrive at the best all-round viscosity to meet the existing requirements.

ALL THE BEARINGS of these straightening rolls at Armco are easily, quickly and efficiently lubricated, as shown here.

* * * *

Where lubrication under comparatively high temperatures may be involved, the question of development of carbonaceous residues within the lubricating system should also be considered. In the circulation of more fluid products any accumulation of non-lubricating foreign matter within oil piping, bearing grooves or orifices of lubricators may seriously impair lubrication. Of course, such matter, while commonly referred to as of a carbonaceous nature, is not by any means all carbon. As a rule, it will include dust, dirt particles of slag or scale and perhaps metallic chips which may have been worn from bearing metal or gear teeth. The binder, however, will be of a petroleum nature.

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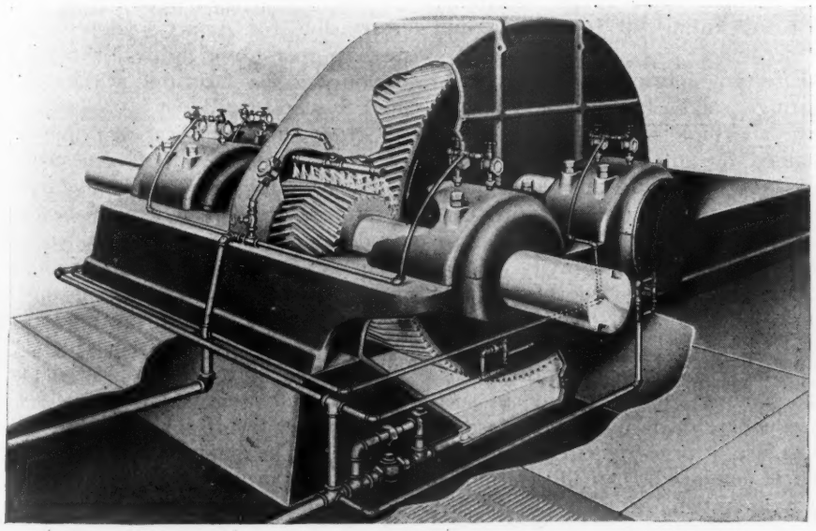
A CIRCULATING oil system as applied to mill drives. Designed to insure continual cooling and flushing of foreign matter.



Under normal room temperatures non-carbonaceous foreign matter will tend to precipitate from lubricating oil provided there is adequate reservoir space available. Nor will oil pipes be as readily clogged inasmuch as these latter as well as the oil grooves will be flushed by the flood of lubricant in circulation.

Should operating temperatures be comparatively high as may prevail adjacent to some types of rolling mills, more or less breaking down or partial distillation of certain oils may occur with perhaps the formation of gummy residual matter consisting chiefly of carbon. It is this matter which should be investigated when selecting oils for such service, for it is the essential cause of subsequent accumulation of non-lubricating deposits as mentioned above.

As a specification or characteristic the carbon residue content of an oil is the important factor in this regard. This content will vary widely both in nature and amount according to the type of crude from which the oil has been produced, and the degree of refinement employed. For example, distillate lubricants will, in general show a considerably lower carbon residue content than will residual products such as steam cylinder oils or heavy gear compounds.

In the former, the carbon residue will usually be considerably below one per cent. In the latter, on the other hand, this characteristic may perhaps be as high as three to four per cent.

It may be generally stated that the carbon residue content will vary directly with the viscosity in oils of the same base which have been similarly refined. In other words a light to medium-bodied air compressor oil as would be suitable for such equipment in the engine room of the steel plant would show less carbon residue than a heavy motor oil designed for truck service. This is, of course, as it should be, for carbon residue in air compressor service must be carefully guarded against at all times, in the interests of maintenance of suitable pressures, protection of valves and reduction of hazards due to overheating should congestion occur in air lines or other parts of the compression system.

The extent to which anti-friction bearings have been studied for application to certain types of rolling

mill equipment requires mention of the fact that the carbon residue content of lubricants intended for such bearings must also be considered both in selection and application.

The anti-friction bearing is very frequently individually lubricated. In other words, except where installed as part of a more or less complex machine, for example, as a thrust bearing for a worm reduction gear, each will require individual attention when relubricating or flushing.

Flood lubrication in such a bearing contained in its own separate housing is not practicable. In fact, normally it is advisable to use just sufficient lubricant in such a bearing to submerge only the lowermost rolling element. This, however, will normally depend upon the grade of oil or grease used, and the recommendations of the bearing manufacturer concerned.

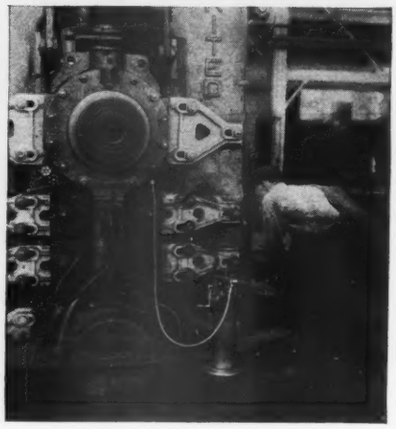
The reason for such careful gaging of the amount of lubricant to use is to reduce the development of internal or fluid friction in the bearing as far as possible.

By this same premise it is also important to reduce the possibility of entry or development of non-lubricating abrasive matter. Housing construction in a properly designed bearing will normally prevent entry of dust, dirt or other external matter which might impair lubrication or score the highly polished surfaces of the rolling elements.

Development of carbonaceous matter, however, must also be guarded against in the bearing itself. Under normal operating temperatures the carbon content of the lubricant will not be so important. Should an anti-friction bearing be subjected to high temperatures, however, there might easily be possibility of the lubricant developing a certain amount of carbon residue. Of course, as a rule where such bearings are to function at these temperatures, heavier bodied lubricants are frequently recommended. It must be borne in mind, however, that such lubricants, especially if of a residual nature such as cylinder oils, or if greases manufactured from cylinder stocks, will have a higher potential carbon residue content at the start. On the other hand, they will not break down or vaporize as readily as will lighter bodied distillate oils.

In this connection the flash point will also be of interest. Broadly speaking the flash point is indicative of how much temperature an oil will stand before vaporization and breakdown will occur to any extent. From a technical point of view the flash point is that temperature at which an oil will give off sufficient vapor to develop an explosive mixture with air, when momentarily exposed to an open flame. The fire point or temperature at which continuous burning will occur, will usually be somewhat higher than the flash point of the lubricant.

In the steel mill, low flash point in an oil exposed to higher temperatures may result in abnormal vaporization and development of gummy residual



LUBRICATION by this method is both safe and positive. The operator here is supplying grease to the bearings of a four-high mill.

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or carbonaceous matter within a lubricating system. The flash point, however, is not regarded as an important indication of lubricating ability. Rather, can it be noted as an indication of the base of crude, and probable viscosity, inasmuch as it varies directly with the latter. Usually, however, the carbon residue content and viscosity are the most indicative characteristics of the suitability of a lubricating oil for rolling mill service.

Effective lubrication of grouped bearings and frequently enclosed gears and pinions can be more nearly attained by automatic circulation of lubricants which are capable of meeting the pressure and temperature conditions discussed above. On certain types of rolling mills gravity circulation of oils has been developed to a marked degree with decidedly beneficial results.

At the Ashland plant of the American Rolling Mill Company, in such cases where oil is used in preference to grease, a pressure circulating system is employed. An illustration of such a system, as used on the bar mill engine and hydraulic pumps, is presented elsewhere in these pages, in connection with the discussion of mechanical maintenance at that plant.

Where practicable without unduly high initial installation cost for extensive piping layouts, it will be advisable to use the same lubricant for both bearings and gears. An instance of where this can very often be done is on reduction drive bearings and gears.

The viscosity of the lubricant must, of course, be such that not only will an adequate film be maintained within bearing clearances at all times, but also positive protection of the gear and pinion teeth assured at the maximum operating pressures which may prevail.

In the driving of heavy duty mills where the load on the rolls may be considerable, reactionary pressures on the drive mechanism may frequently be decidedly high, even though not continuous at all times.

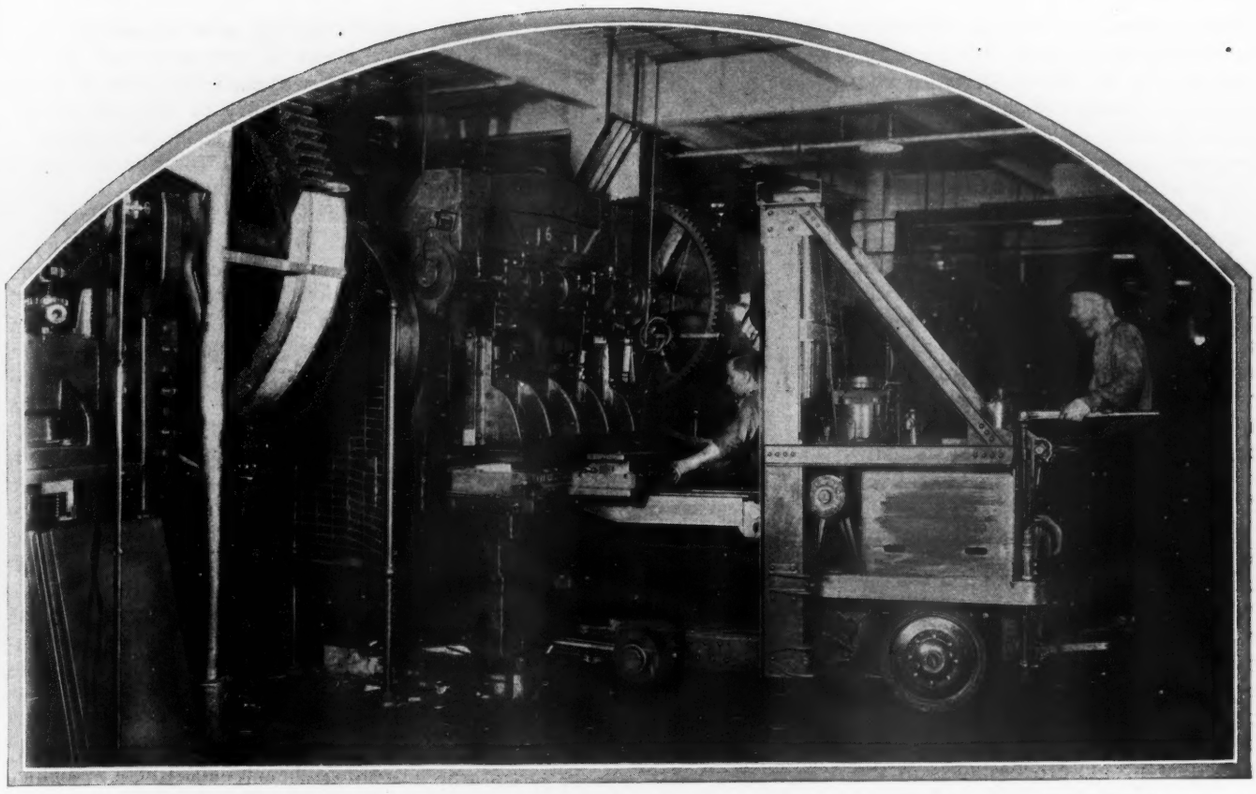
To meet these pressures, as well as to withstand the reduction in viscosity which may occur at bearing temperatures in the neighborhood of 160 deg. F. a comparatively heavy bodied lubricant may be required, as discussed in an earlier part of this article.

There is also a marked tendency towards the more extensive use of a grease wherever plain or anti-friction bearings are involved which can be equipped with fittings which will enable ready use of a pressure grease gun.

Also, where steel products are involved which might be marred as to surface or finish by dripped or splashed lubricants of a comparatively fluid nature, grease lubrication as above has been found to be decidedly advantageous.

This is probably one of the factors responsible for Armco's adoption of modern grease lubrication for its continuous process sheet mill at the Ashland, Ky., plant.

Grease effects lubrication by virtue of its oil content. If of consistency commensurate with operating temperatures, grease can usually be depended upon to retain its intended form as a more or less inert product, and withstand any tendency towards dripping, even though squeezed out from the ends of a bearing. In fact, such grease as may be squeezed out will generally serve as a virtual seal to prevent entry of abrasive dust, dirt or scale. The extent to which a bearing may be protected in such cases is decidedly marked.



Idle time of presses is cut to a minimum by the use of the electrical industrial truck for changing heavy dies.

New Ways to Improve Plant Conditions with

Electric Trucks and Tractors

BY C. B. CROCKETT

Society for Electrical Development, Inc. and Chairman, Progress Report Committee A.S.M.E. Materials Handling Division

DURING the past ten years most industrial plants have been surveyed and re-surveyed to investigate possibilities for making transportation of materials through processes more effective. Plants constructed during this period have in many cases been designed around plans providing, first of all, adequate facilities for materials handling. It can no longer be said that opportunities for more economical movement of stock through the plant are being ignored.

The fact remains that the only saving commonly associated with improved materials handling practice is that made in avoiding needless expenditures for so-called non-productive man-power. While it is true that this saving is often greater than any other that is traceable directly to the use of the particular equipment in question, some plants have found that other savings have been of more vital significance than the direct cut made in the labor cost of handling.

How, one may ask, can this be the case, when handling equipment is designed specifically to transport materials? The answer is that it is the methods made possible by the equipment, rather than the equipment itself, that are responsible. The reason that opportunities to capitalize these indirect savings are so frequently overlooked may be traced partly to the fact that the unwieldly and unsatisfactory item of unanalyzed production overhead conceals them.

What effect, for instance, does the proper use of modern power handling equipment have upon the space requirements for unit production? Can this equipment be used to speed up strictly production machinery? Can it be relied upon to lower labor turnover? To decrease hazards to workmen throughout the plant? To lessen inventories of materials necessarily held in the plant? To improve plant ventilation? To lower insurance rates? To lessen the cost of ordinary routine plant maintenance operations? To lessen car demurrage?

These are some, not all, of the questions that must be asked when the pressure to decrease production costs

becomes intense. The item of breakage of fragile materials, for instance, may be one of first importance and one to be minimized through proper installation and operation of handling equipment.

Costs and other data are not available, based on the experience of any one plant, using all representative types of materials handling units, but it is possible to show what one widely useful type of equipment is doing to roll up indirect savings, in a wide variety of operations. We propose to outline what electric industrial trucks and tractors have been found to accomplish in many plants and in many industries where it is now recognized that the last frontier for making handling savings lies only partly in further increasing directly the capacity of unskilled workers.

Every square foot of area in the modern plant must have earning capacity. This capacity must depend upon the use made of the space. Because electric trucks, particularly of the low- and high-lift types, are designed to promote orderliness in the handling of stock as well as the storage of materials in compact form, their use paves the way to savings in this direction. A Chicago plant has to store four times as much material at some periods as at others. High-lift trucks, suspending skids from the ceiling, make it possible to increase normal storage capacity sufficiently to care for peaks.

An Ohio steel plant turning out strip once faced such a serious problem of congestion, when cranes and

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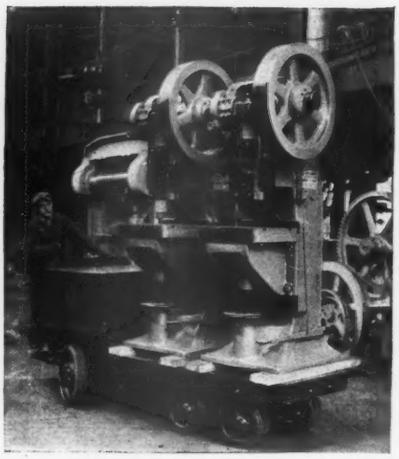
WHEN ROLLS OF STRIP are handled by the industrial truck the size of the roll can be increased so that the production machines have to be shut down less often for loading.



MOVING PRESSES of this size with rollers and manpower is a slow and dangerous job. This 10-ton electric truck does it as one of a number of odd jobs, in addition to its regular service.

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hand trucks were depended upon exclusively for handling the output of the rolling mills through succeeding operations, that the entire plant had to be shut down periodically to put the stock in order. Then ram trucks using storage battery power were installed. Although the direct saving in man-power was considerable, the greatest saving came in the orderly dispatch with which this new equipment kept material moving. Three years after installation the earning of each unit was considered to be equal each month to its original purchase price.

One automotive plant that is considered to be a pace setter employs special heavy-duty type lift trucks almost entirely for moving the hundreds of items of stock that have to be kept flowing constantly to the assembly line. Over a period during which capacity in this plant was increased 500 per cent, manufacturing area was increased only 25 per cent and the storage area actually was decreased by 33 per cent. A further economy was made possible by a decreased inventory of materials in the plant; this being reduced to the normal requirements for approximately four days of production.

Particularly in the smaller plant, however, there is almost invariably opportunity for cashing in on this possibility. The electric truck does its work and goes on to another area where work needs doing. One cotton mill, storing baled stock in its basement, rams bales into place with a platform truck and finds it possible to place 33 per cent more bales in a given area by this method. The same truck, incidentally, with a broom attachment has cut the labor required to sweep the plant by more than 80 per cent.

In some plants where congestion of workers and stock is very great, electric trucks move in materials for the following day's work, at night, and at the same time carry out the finished production of the day just finished; working in each department and eliminating necessity for keeping crane and craneman for each department. In still others this equipment is used to bank production lines with stock in large units so that the truck itself is on the scenes only periodically.

The orderliness that results from proper use of power trucking directly introduces, in some sections of the country, the possibility for a particularly desirable fire and water insurance rate. Storage of stock off the floor, either on skids or trailers, fre-

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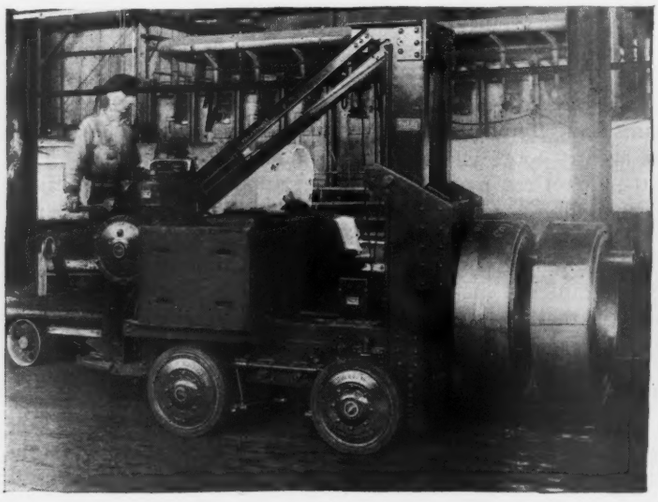
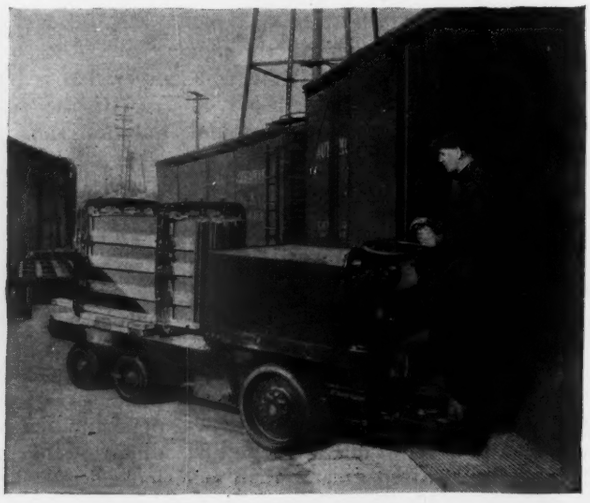
AN AUTOMOBILE PLANT in Detroit receives sheet steel in 10-ton bundles and handles it as shown above. The reduction in damaged sheets alone amounted to $3.40 per ton.





quently makes possible this premium for good housekeeping. In one large sugar refinery, this factor of saving through the use of battery storage equipment is considered as of first importance. Because of the entire absence of fire hazard, electric truck use is permitted for handling practically all types of material. The fact that no fumes are involved in its operation, makes it an advisable unit for inside work, particularly in closed quarters where many workers are employed.

The business of plant maintenance is one for which the electric also is ideally suited. Although in the smaller plant frequently the time required for this work is almost negligible, the value of the service rendered may be great. A Long Island, N. Y., paper plant bought a high-lift truck primarily to carry coal from outside storage to the hoppers feeding the automatic stokers, but found that in spare time it could be used to excellent advantage for moving baled paper from yards to beater room. Another plant in Detroit that bought crane trucks for routine handling found that in the service of the millwright gangs so much useful work could be done in this way that it became necessary to purchase four units for this service. The work consists almost entirely of moving machinery in a plant where production areas are necessarily shifting and growing constantly. Each of the units in this case is credited with a direct saving equivalent to the wages of 35 men. Still another truck of the crane type, used in the steel industry,

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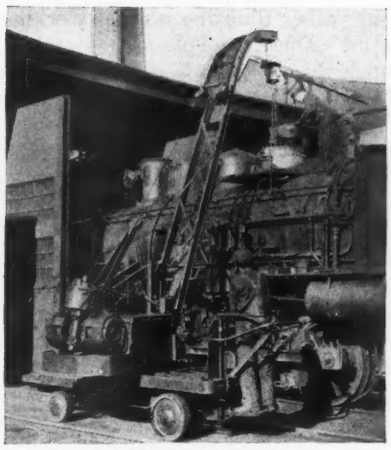
IN MODERN PLANTS special trucks are often fitted up for the use of the electricians, pipefitters and others who are responsible for keeping the machines running.



CRANE TRUCKS with collapsible booms perform a multitude of tasks in railroad repair shops, foundries and machine shops. This one is used in stripping a locomotive.

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puts in spare time carrying an electrician about the yards on the elevated platform, to replace carbons in the arc lights used for illumination.

In a large railway repair shop, an operation that proves the value of pinch hitting in spare time, consists of carrying turnings to outbound cars. This method makes it possible to do the work in approximately 5 per cent of the man-hours required when wheelbarrows were used.

High-lift trucks can be used in the plant for carrying workers to the ceiling of lower buildings for work on pumps, shafting, lighting equipment and piping. One plant uses a truck in this way for painting. In another plant, a crane truck is used periodically for work in the garage for heavy lifting of various kinds.

The spare time uses of electric truck equipment are legion; the practical saving capacity of the units so used is great. For spotting freight cars, for instance, in the absence of a regular locomotive, the storage battery unit is an effective pinch hitter. In a sense the efficiency of such a power aid is greatest when its operating capacity is taxed.

A steel mill uses a specially modified ram truck with a key inserted at the end for moving rolls in and out of the rolling machines. Many plants use their electrics with simple tackle for odd jobs of hoisting. Several find a use for their equipment in pulling wire through conduit. Others put the power unit to work in spare time for delivering non-production supplies throughout the plant.

In one case, an electric fitted up with a complete equipment for repairs to the electrical equipment in the plant is used as a standby for emergency call, very much as is the wrecking train in the terminals of most railroads. This investment has been found well worthwhile. Another metal manufacturing plant found it worthwhile to build special skids for oil tanks and now makes it part of the routine for one truck to deliver oil to all departments using it. Such procedure now saves needless expenditures of the time of skilled workers who otherwise might go for their own supplies. In one plant where a study of the time spent for this particular errand was checked, it was found to amount to 60 man-hours a week.

Where production equipment is fed manually the limiting factor in continuous operation frequently is the weight of the unit that can be handled by the attendant. In the case of

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STORAGE CAPACITY was increased and labor costs cut by tiering these barrels four high, and the saving more than pays for the equipment.

bundles of wire fed to a nail machine, for instance, a man cannot easily swing much more than 150 lb. With a crane truck for such service, a 300-lb. bundle is not impossible and even a greater weight can readily be put in place if there is room for the heavier unit of material. Stopping a machine half as often greatly increases its output per day. In such service as this the crane truck and the high-lift have run up spectacular savings.

For die changing, where electric high-lifts are used for pulling off and placing dies as needed, the time required is minimized; operating time is increased and output rises accordingly. That is why it is possible to credit some trucks in this service with a saving amounting to more than $200 a day. It is not the saving in direct man power that makes this figure possible, but rather the fact that idle time for expensive production equipment is minimized.

Where heat treatment is required, as in the malleable foundry or the steel parts plant, another item of saving enters where properly engineered trucking equipment is applied to the handling operations involved in the charging and discharging operations. Although in moving in and removing the boxes in a heat treating plant the direct saving may amount only to ten or twelve men a day per truck in full time service, the saving made in heat and at the same time in capacity of the furnace is of first importance. No appreciable heat need be lost when a fork truck is used but when the furnace has to be opened long enough to permit handling by older methods, much time may be lost in bringing it back to full heat. In malleable furnaces, the electric has demonstrated its capacity to work in and out of the heating zone when it is still as hot as 600 deg. F.

The question of turnover is another that is real, yet particularly difficult to discuss. One department in one foundry was constantly hiring and firing men up to the time electric lift trucks were installed about four years ago since which time the turnover has not existed. While the workers engaged were only semi-skilled, the cost of turning over one man could not have been less than $50 to $100. A patent leather producer found that a difficult problem of hiring a large number of workers for short time service in the sunning yards was eliminated when lift trucks and special skids were put to work because this equipment made it possible to care for peaks in activity without using other than the normal working force. These are but isolated and inconclusive cases of the effect this equipment has in lowering labor turnover but may point the way to constructive studies elsewhere.

So far as managerial overhead is concerned it is only possible to state that with unskilled workers the amount of overhead varies directly with the number to be supervised and that with effectively operated handling equipment this number is reduced to a minimum.

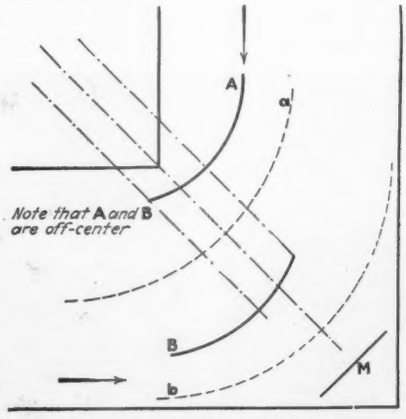
No brief presentation of this sort can pretend to be comprehensive. The movement toward skid shipment of materials of many kinds invites a discussion by itself. But here again, the equipment used primarily to conserve manpower in moving material through the plant makes possible a very great labor saving both in loading and unloading freight cars—and in freight car demurrage where the method is measured against that possible where manual handling is relied upon exclusively.

The opportunity for increased savings from the use of equipment such as the industrial truck and tractor is great. Also, there are possibilities of improving plant conditions.

Collision-Proof Corner for Two-Way Traffic

BLIND corners find no place in modern factory planning, but when, as was the case with the Banks Pottery Company, the plant is composed of buildings dating anywhere from 1870 to the present, a blind corner is encountered occasionally which cannot be eliminated without too great expense.

One such corner is diagrammatically represented in the accompanying sketch. The two-way traffic consisted principally of electric trucks and trailers carrying green-clay castings from the side marked *B* and returning empty from *A*. At first the right-angle bend was without any provision to prevent collisions and mix-ups were frequent. These were attributable largely to the natural tendency of the operator of the loaded tractor to bear to his left on rounding the curve.



LAYOUT OF GUIDE RAILS for tractor at blind corner. To prevent collisions the two angle-iron guide rails *a* and *b* were installed but these interfered with wide loads and tended to cramp the wheel toward the outside. The shorter guide rails *A* and *B* guide the inside left wheel just around the corner.

To obviate this, someone had installed angle-iron guard rails at *a* and *b* to try to guide the traffic around the corner. The rail *a*, coming as it did in the center of the aisle, interfered with the passage of the occasional truck loaded with material which required more than normal clearance. In addition, the rubber-tired tractor wheels clung against the elevated rail and tended to drag the wheels outward, thus cramping the steering toward the outside of the curve and into the wall.

To clear the center of the aisle, and also to give a form of guard which would aid in turning the wheels in the proper direction, the short rails *A* and *B* were formed and installed so as to catch on the inside of the left front wheel as the tractor approached the corner and guide it until the operator was in the clear. The radii of these short guard rails were taken as one-half the width of the aisle; also instead of being installed with the centers of their arcs of curvature on the center line of the bend, they were set off-center in the direction of traffic an amount equal to one-half the wheel gage of the tractors.

With the new guard rails in place, it was possible to handle a load as wide as the clearances would permit, and yet find room for the truck wheels between rails *A* and *B*.

After the two improved guards had been installed and a mirror 4 ft. square hung at *M* so that drivers could see each other, collisions at this corner were practically eliminated and the placing of blame for the infrequent crash readily determined.

Savannah, Ga. ELTON STERRETT.

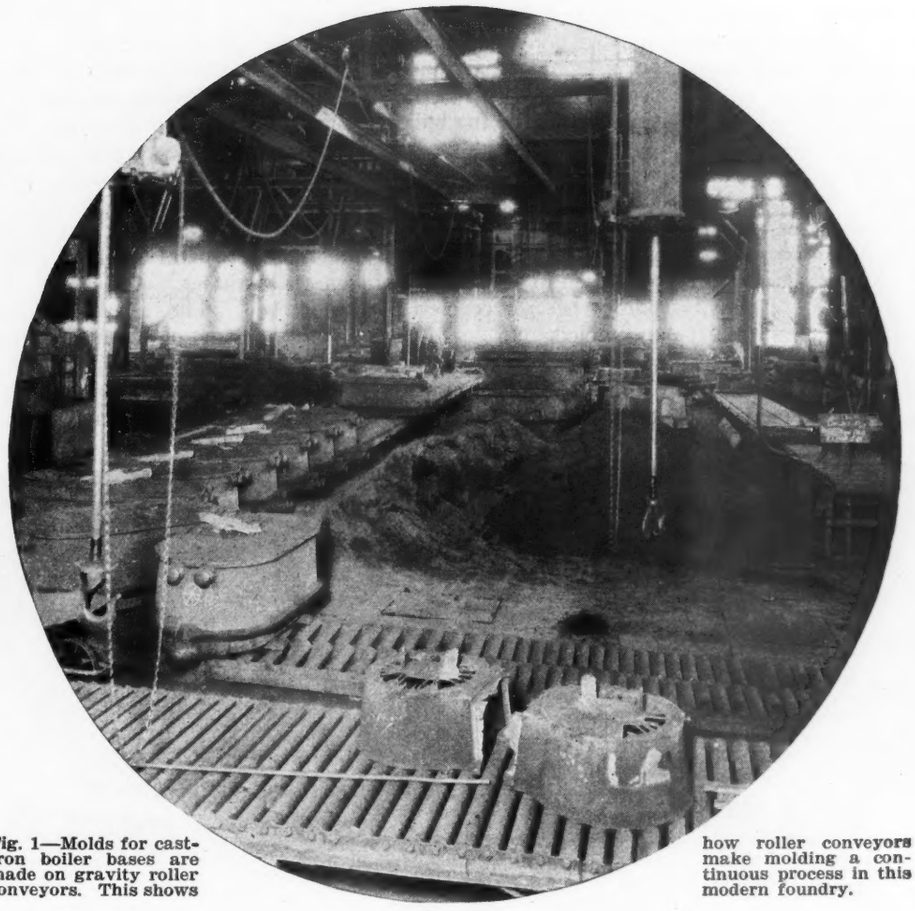


Fig. 1—Molds for cast-iron boiler bases are made on gravity roller conveyors. This shows how roller conveyors make molding a continuous process in this modern foundry.

Gravity roller conveyors

Cut Handling Costs

in the modern foundry

By E. J. TOURNIER
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WE ARE all accustomed to the idea of continuous manufacturing and progressive assemblies, as exemplified in the automotive industry, and it is a well-known fact that the necessary continuity is accomplished by means of conveyors. The motor-car assembly line is a familiar piece of equipment that is frequently seen in advertisements. The progressive assembly of engines, rear axles, steering columns and of the completed automobile are all in the day's news.

Following the example of the automobile factories, many other industries have found it profitable to substitute wherever possible mechanical handling of parts for hand labor. The extensive systems for handling materials in automotive foundries are being duplicated in bath tub foundries, radiator and steam boiler factories and in jobbing shops.

In every continuous-process foundry there are three principal classes of materials to be handled. These are molds, castings and sand. Examination of foundry expense shows that a large tonnage of these materials must be moved, and that the cost of moving them is greater than the cost of making castings.

For example, in the foundry of a large automobile factory 69 tons of materials are moved for each ton of castings produced; in a bath tub foundry, 137 tons of materials are handled for each ton of castings. A large jobbing shop moves 200 tons of materials for each ton of castings delivered to the shipping platform. Of these large tonnages, molds and castings average a total of about 40 per cent and, therefore, constitute a major handling problem.

A large manufacturer of cast-iron radiators and boilers, in Buffalo, N. Y., is not only handling molds and castings on gravity roller conveyors but is also assembling the finished boilers on this equipment.

The daily capacity of the foundry is 800 tons, which, in the ratio of 5 to 1, means handling 4,000 tons of molds and castings each day. Each part of the boilers is molded and cast in a section of the foundry reserved for this work, and each section is served (Fig. 1) by lines of gravity rollers and pneumatic hoists for lifting the heavy molds. At one side of the foundry the bases for round boilers are cast, two in a mold.

The assembly of the bottom sections of the boiler consists in fitting grates and doors to the bases. Two lines of conveyors are used for this purpose and are arranged for the reception of castings from the storage yard outside of the building. Stacked in piles about the assembly room are rows of bases, grates, doors and parts for the tilting mechanism of the grate bars. The two assembly lines form a rectangle in the center of the room, as shown in Fig. 2, and branch off at one corner to receive the parts to be assembled.

At the corner diagonally opposite to the loading point one long side of the rectangle is extended past the point where the short side joins it to close the figure. The extension referred to has its extremity made in two parts. These two sections are separate from the main conveyor and from each other in order to accommodate a scale and a spray-painting outfit.

The assembled bases are moved onto the scale section of the conveyor, one at a time, and the weight recorded. From the scale the bases are passed on to the paint section where they are sprayed with quick-drying paint. Immediately after being painted the finished bases are lifted from the conveyor line and placed in shipping crates. The latter are piled near the spray-painting section so as to be easily accessible.

Although the rate of travel of the various parts along the gravity lines is not subject to variation at will, the grades are so carefully adapted to the work that progress is smooth and uninterrupted.

Manufacturing the firepots and water domes for the boilers is carried on by the same methods employed for the bases and, except for the operation of assembling the pots, all work is done on special Mathews gravity roller conveyors, as seen in Fig. 3. The assembly in question is accomplished by the use of a power chain conveyor. because that type of equipment is more suitable to the conditions to be met. Molding, pouring and returning empty flasks to the molders is performed by the same general method used in making the bases.

The assembly conveyor for firepots deserves mention, however, on account of its unusual construction. This equipment (Fig. 4) consists of a single strand of steel chain passing around terminal sprockets at both ends of the conveyor, which is 185 ft. long between the head- and tail-shafts. The top strand of chain is equipped with roller attachments equally spaced along the length of the chain. Each attachment consists of three rollers which are free to turn on steel pins. In the processing of the firepots the latter are each placed on the conveyor so as to rest on two sets of rollers. Whenever it is necessary to expose a different point on the cylindrical surface of the casting, it may be rotated on the rollers of the chain attachments.

In order to allow time for working on the castings the conveyor is operated at a very slow speed, in this case 3 ft. per min. On the conveyor, core wires are pulled out, hand chipping is done, and the outside surfaces of the pots are ground free from fins, before they eventually reach the in-

FIG. 2—ASSEMBLING the bases of cast-iron boilers. The assembly line is arranged for easy access to small parts placed within the four sides of a rectangular conveyor installation.

FIG. 3 — THESE CAST-IRON water domes are being transferred between machine operations. Molding and pouring of these castings is carried out in the same manner as employed for the bases.

* * * *

Each mold after being filled weighs about 4,500 lb., and rests on wooden skids which are carried by the rollers. The molds are filled in roll-over molding machines, to which prepared sand is delivered mechanically. After leaving the pouring zone the molds pass down the gravity line to a shake-out hopper. From this point the empty flasks are carried by a second line of rollers to the molding end of the foundry. It is to be noted at this point that the ordinary type of light, industrial gravity rollers would not be suitable for the work. The rollers used in the present instance are constructed of heavy-duty steel tube, with specially-designed ball bearings.

After the bases have been cast they are cleaned by sandblasting and rough ground. They are then placed on a gravity roller conveyor for transfer to the assembly room.

spection station. At this point, each firepot receives a 5-min. water test during which they are rolled on the chain rollers so that all parts of the cylinder may be inspected.

A bath tub foundry in Blairsville, Pa., is doing some of the heaviest work which gravity roller conveyors are called upon to perform. The molds when poured weigh 10 tons each and are carried on heavy-duty Mathews carriers.

The system in use at this plant consists of four lines of gravity roller conveyors, each line being made up, Fig. 5, of two runs or strands of conveyors. One of the lines carries molds, which are filled from overhead sand hoppers. A second line, Fig. 6, carries molds that have been rammed but have still to receive the copes. The latter are handled by air hoists carried on monorails. The third line is used in the pouring zone, in which metal is handled by another overhead trolley and an air hoist.

The fourth line is used for the return of patterns to the molding line. This conveyor is provided with a pivoted section at the end of the pouring line and is arranged in such a manner that an air hoist elevates one end of the pivoted section. The empty molds are placed on this section and the additional lift provided by the hoist starts the pattern toward the molders' section.

Transporting the heavy loads imposed by the class of work these conveyors handle requires an unusually rugged construction of parts. The side frames of the carriers are heavy steel bars with crossbraces between the sets of rollers, which are made of extra-heavy steel tubing. Each ball bearing of the rollers is designed to carry a load of 3,000 lb., thus insuring an ample factor of safety.

The application of gravity roller conveyors for continuous production is not limited to large foundries where a complete system is required. It is possible to segregate certain classes of castings even in a wide range of manufacture, and obtain for the segregated classes at least a part of the possible savings. Special knowledge of the possibilities will enable the engineer to point out how the work may be confined to a certain part of the floor and simple equipment installed. Even in those foundries where segregation of similar castings is not possible, the use of single units may result in large savings.

As an example, a small iron foundry in Reading, Pa., produces a variety of castings consisting of small gears, sprockets, bearings, etc., for an elevator builder and for a manufacturer of inexpensive contractors' equipment. Investigation showed that the daily capacity varied from 5 to 10 tons and was, therefore, of an irregular nature. As the castings did not average over 20 lb. each in weight, most of the molding was bench work. Owing to the difficulty of deciding beforehand the amount of the daily melt, there was frequently an overrun which resulted in losses of iron.

Examination of conditions revealed the fact that over one-half of the castings were very similar in shape and size, and that a continuous pouring schedule could be devised for this part of the work. The foundry was then rearranged so that the molds for production work were made in a part of the shop set aside for the purpose. Immediately back of the molders' bench a gravity roller conveyor was located so that the flasks could be placed on it by means of a chain hoist. A small overhead trolley was installed over the conveyor for handling the iron ladle which was manipulated by one man.

The installation of this equipment resulted in a saving of over 50 per cent in labor cost and at the same time nearly half of the over-run was saved because of the ability to calculate requirements more closely.

A great deal of discussion has appeared in foundry trade papers regarding the competition that iron castings meet from various sources, such as die castings, sheet steel stampings and welded steel parts. The element of the cost of castings has much to do with this situation, if consideration is not given to those special cases where the relative weights of parts are important factors. It is of interest, therefore, to note that these same publications are emphasizing to their readers the necessity for a close scrutiny of their operations in order to ascertain whether they cannot, in many cases, substitute mechanical handling for muscle power.

Foundries are among the very oldest industries of mankind. Like most industries rich in tradition, they have been slow to adapt themselves to newer and better methods. The more progressive, however, are pointing the way, and economic pressure, if nothing else, will force improvement.

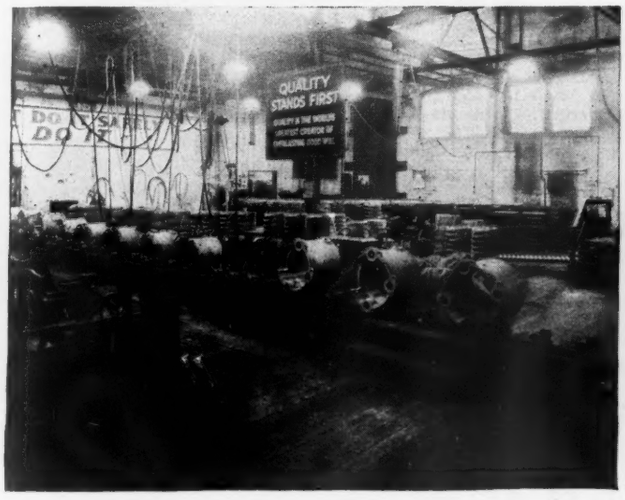

FIG. 4—HERE A POWER CONVEYOR is used as an auxiliary to the gravity rollers. Firepots brought from the foundry for assembling are inspected and tested on this unusual type of conveyor.

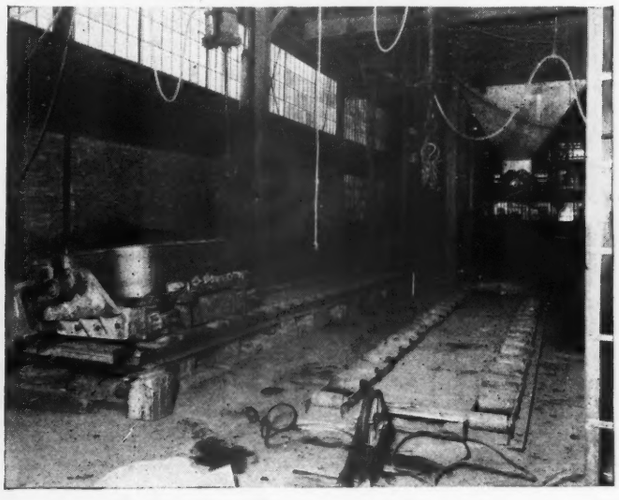

FIG. 5—GRAVITY CARRIERS in this bath tub foundry must handle unusually heavy weights. A line of double-strand rollers carries the empty molds, which are filled from overhead sand hoppers.

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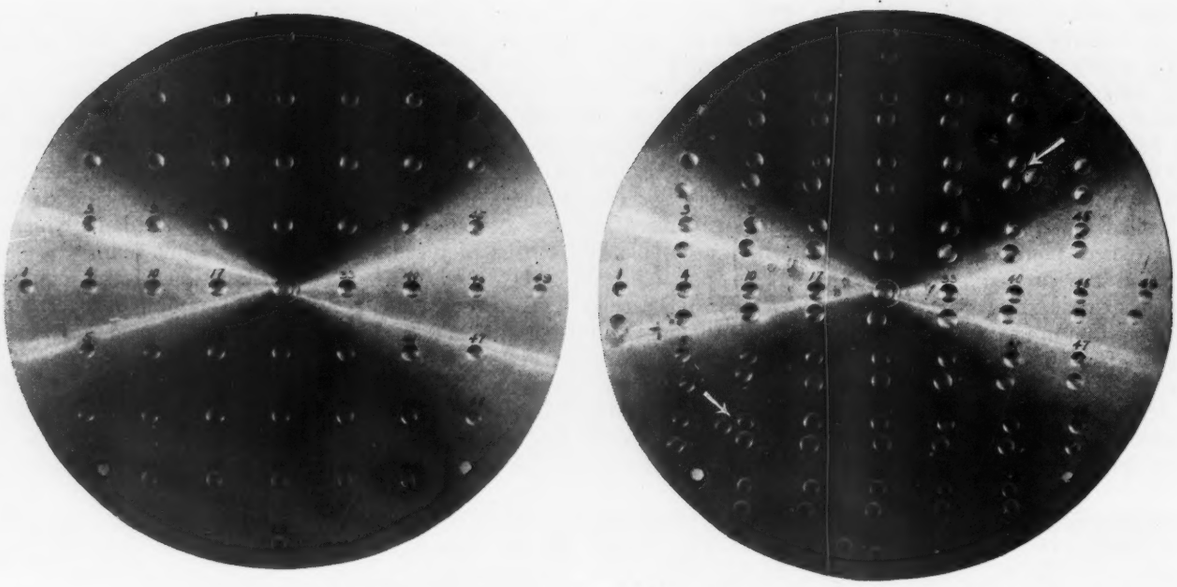

Figs. 1 and 2—Brinell test plates. The one at the left shows a plate with the impressions produced by the test. At the right, the same plate after duplicating the impressions in an Olsen testing machine.

Load and Power Tests on Anti-Friction Bearings

for Steel Mill Service

By S. M. WECKSTEIN

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THE RESULTS that have followed the application of anti-friction bearings to heavy-duty rolling mill equipment of various kinds have aroused great interest in their possibilities among both the users and manufacturers of such equipment. As a consequence, there is much investigation in progress at present to determine the suitability of anti-friction bearings for the different machines included in that category, and to ascertain just what the benefits may be that follow their use. The starting point of any such investigation is, naturally, a determination of the loads that will be imposed on the bearings under actual operating conditions. Under the circumstances, a consideration of some of the methods adopted by the bearing manufacturers and machine builders for arriving at accurate results in load determination may be of interest.

When the question of the application of anti-friction bearings to steel, or non-ferrous rolling mills, and similar equipment, first arose there was very little exact information available concerning the pressures that the bearings would encounter under operating conditions. It was therefore necessary for bearing engineers to devise some method of determining actual rolling loads with sufficient accuracy to form the basis for the design and construction of the bearings. The problem was further complicated by the fact that, in many cases, it would be undesirable or even impractical to shut down the mill that was to be tested, or even to interrupt its operation to any considerable extent. Two such test methods have been developed, both of which have been carefully checked against each other, and against other theoretical methods of load calculation. The results obtained by both have been found sufficiently accurate to form the basis of proper bearing design.

The two methods differ considerably in their physical aspects, but the underlying principle is the same for both. One method is known as the Brinell test and the other as the hydraulic cylinder method.

The Brinell test is by far the simpler of the two, but it necessitates the use of auxiliary equipment to calibrate its results after the actual test has been made. The apparatus used consists of two steel plates, of sufficient size to withstand the imposed loads. One plate has a hardness of approximately 45 Scale "C" Rockwell, and is ground smooth on both faces. The other is slightly thicker, is well hardened, and has a number of spherical recesses drilled on one face to receive a number of hardened steel balls. The depth of the recesses is usually about one-

fourth of the diameter of the ball. In order to facilitate handling, the two plates and the balls are assembled in a sheet-metal retainer that makes a single unit of the whole assembly.

The plates are installed in the mill to be tested as follows: The mill screws are loosened, and the breaker blocks removed. The test plates are inserted with the smooth plate on the bearing chock. After the unit is centrally located under the mill screws, as shown in Fig. 3, the screws are run down to engage with the top plates. The mill is calibrated for rolling, and operation is started. When the work goes through the mill the spreading force acting on the rolls is transferred to the plates of the test apparatus, producing Brinell impressions on the smooth plate. Fig. 1 shows such a plate after test, and gives an idea of the depth of the impressions produced. When the rolling operation is completed the plates are removed from the mill, and each depression left by the balls on the smooth plate is measured under a magnifying glass, an exact record of its diameter being kept. The plate is then put in an Olsen testing machine, where each impression is carefully duplicated. Fig. 2 is the same plate as that shown in Fig. 1, after the duplications have been made. It will be noted that at times it was not possible to secure an exact duplication at the first attempt. The pressure required to duplicate each impression is carefully recorded, the sum total of all these pressures giving the total load on the side of the mill on which that particular plate was located.

When the test is to be made on a piercing mill, or on any machine where the test plates must be held in a horizontal position, a sheet-metal retainer of a width less than the combined width of the plates and balls is used. Aside from this feature the method of locating the plates in the mill is similar to that just described.

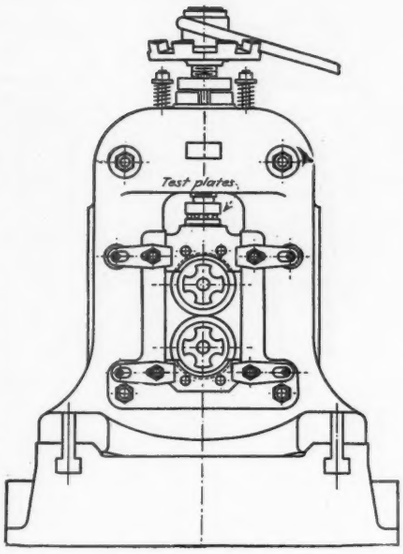


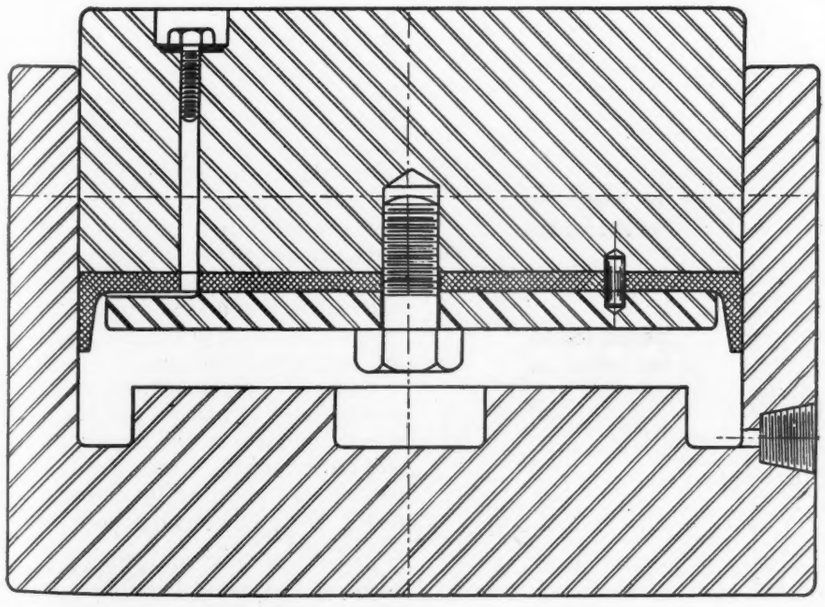
FIG. 3—MAKING a Brinell load test on a vertical rolling mill. The plates and balls are inserted in the space usually occupied by the mill bearing block.

* * * *

The hydraulic cylinder method was developed for use in cases where it is desired to obtain not only the maximum value of the rolling loads, but a complete record of load variation at different points in the rolling operation. The apparatus used with this method consists of a hydraulic cylinder, and a Bristol recording pressure gage. The cylinder used in this test consists of two parts, the cylinder proper, and the plunger. In operation, the space between the cylinder head and the plunger is filled with glycerine or oil. The plunger is equipped with a leather gasket, and is also provided with a valve which permits the escape of any air that may be trapped during the process of filling the cylinder with glycerine or oil. The complete assembly is shown in Fig. 4. Connection with the pressure gage is made by means of a flexible tube which screws into the cylinder wall. After the gasket on the plunger has become thoroughly saturated, and all the air has been forced out, the apparatus can be calibrated permanently with respect to the scale readings on the pressure gage. There is one limitation to the use of this method. In some cases the large diameter of the cylinder makes it impractical because of restricted space in the machine to be tested.

* * * *

FIG. 4—SECTION of the cylinder used to obtain load data by the hydraulic cylinder methods. The tube to the recording gage screws into the hole on the right of the cylinder.



When a test is to be made with this apparatus, the cylinder is placed in the mill in the same manner as that described in the case of the Brinell method. When the piece is rolled in the mill the spreading of the rolls forces the plunger into the cylinder, the hydraulic pressure created being transferred to the recording gage, and is read directly from the chart. The exact load is determined by comparing the chart readings with the calibration curve that has been made on the cylinder.

Probably the best way to illustrate the procedure followed in making load determinations is to give a detailed description of an actual test. As a matter of further interest the roll neck bearing arrangement that was developed as a result of the test is also given. The machine in question was a seamless tube piercing mill. The original reason for making the tests was the possibility of eliminating the cost of plain bearing replacements. This cost ran as high as $12,000 per year for bearing brass alone, no account being taken of the expense for labor and maintenance required to keep the bearings working properly.

The former arrangement of the mill, and the method of locating the Brinell plates, are shown in Fig. 5. It will be noted that four screws are used to obtain adjustment of the rolls, the screw pressures being transmitted through a special collar pinned to the end of the screw. In order to

make the test, two of these collars were removed and Brinell plates inserted in their place, as shown. After the plates were centrally located, the mill screws were run in, and a billet was entered between the rolls for piercing. The billet was 6 in. in diameter and 75 in. long; the hole pierced had a diameter of 4½ in. The spreading action of the rolls during operation made impressions on the smooth plates, which, after duplication, showed total loads of 81,000 lb. on the drive side, and 71,400 lb. on the finish side respectively.

With this information, and with a knowledge of the speed of the rolls, the first step towards the design of a bearing suitable for the service was made. In this particular mill, however, the bearings are also called upon to withstand a heavy thrust load caused by the character of the mill operation. A second test was therefore necessary to determine the magnitude of this load, which was done by obtaining the Brinell pressures on the thrust block. It was then possible to complete the design of the bearings. The bearing arrangement that was actually developed as a result of these tests is shown in Fig. 6. The bearings have been in operation in our own mill for 10 months, with no sign of trouble. As a matter of fact, inspections that have been made at periods when the mill was down for roll replacement have shown the bearings to be in excellent condition.

Another operating feature of this mill that developed after the roller bearings had been installed is of interest—the power savings that have been effected. It was decided, after the bearings were put in operation, to run a series of comparative tests to determine just what, if any, saving in power was directly traceable to the roller bearings. Since the mill is used to pierce tubes of varying analyses

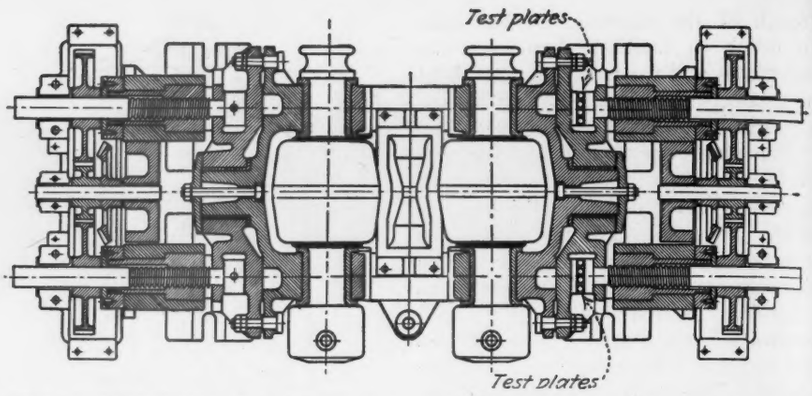


FIG. 5—LOCATION of plates for a Brinell test on a piercing mill. The plates are put in the place of the collars on the ends of two adjusting screws.

* * * *

and diameters, and since every change in tube diameter necessitates a different setting of the mill, and a different angle on the rolls, it has been rather difficult to obtain comparative data on tubes. It has been possible, however, to obtain some information on the difference in power consumption between plain and roller bearings working on tubes of the same diameter and analysis.

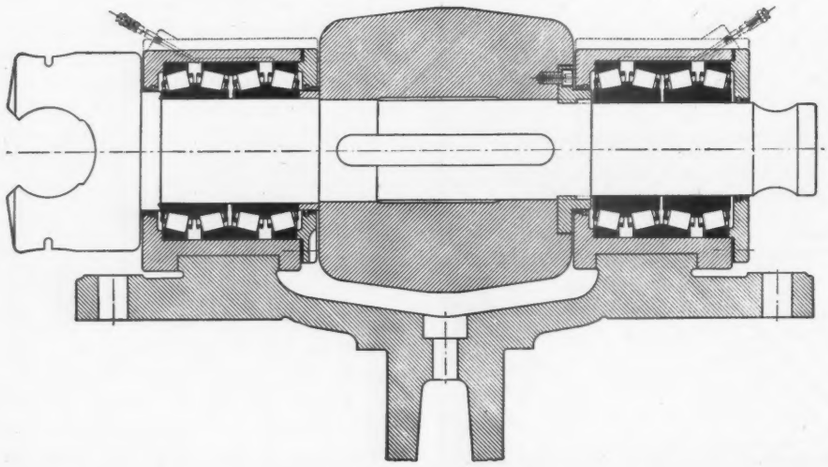
In carrying out these tests, every factor that entered into the mill operation was given consideration. The mill is driven by an 800-hp., 2,300-volt, three-phase constant-speed induction motor. The speed is reduced from a motor speed of 260 r.p.m. to a roll speed of 180 r.p.m. by a gear-reduction unit. The power consumption of the mill was measured by an Esterline-Angus curve drawing recording watt-hour meter connected in the motor circuit. By an arrangement with the mill operators, the mill was run alternately on plain bearings and roller bearings. During the test each billet rolled was weighed and measured, before entering the mill, and its temperature while in the mill determined by means of an optical pyrometer. Careful record was kept of the time the billet was in the mill and of its temperature.

A study of a large number of tests, under all possible conditions of tube diameter and analysis shows that the power savings range from a small percentage on the smaller tubes to as high as 25 per cent on the larger tubes.

Although this saving in power is not quite as large as that which has been accomplished in two, three, and four-high rolling mills, or in cluster mills, the application of roller bearings to all types of piercing mills would seem to be justified; the elimination of costly plain bearing replacements, and high maintenance charges being an important factor.

* * * *

FIG. 6—BEARING arrangement for piercing mill, developed as a result of data obtained from the test illustrated in Fig. 5.



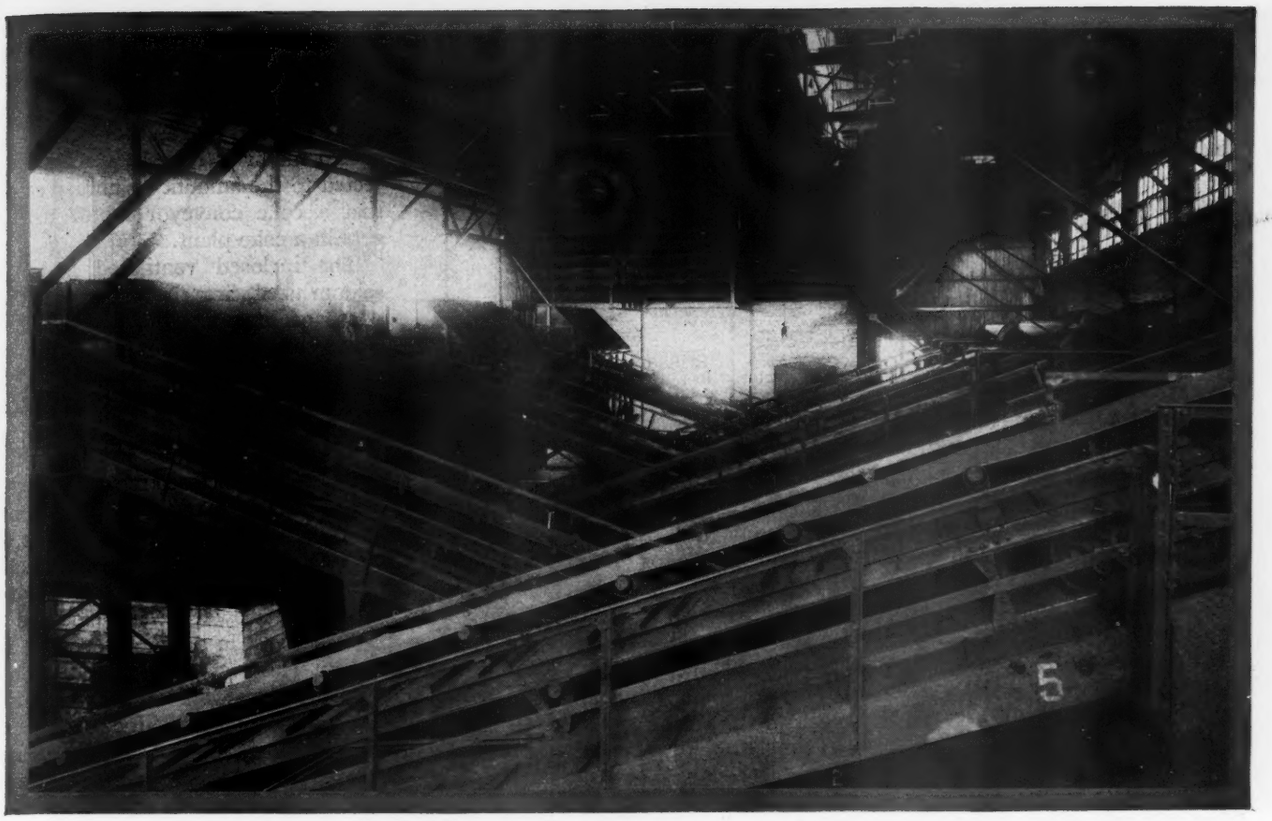
Compressed Air Used to Remove Cause of Excessive Sparking

A MEDIUM - SIZED, enclosed-type, ventilated motor was used to drive several high-speed grindstones. After the motor had been doing this work for a few weeks, the operator noticed excessive sparking at the brushes and occasionally a flashover. The usual remedies for commutation troubles were tried but made no improvement.

When the air gaps between the armature and the field poles were examined it was found that small particles of iron and steel grindings had been attracted on to the pole shoes by the magnetic field.

It was thought that there was just enough iron particles on the pole shoes to unbalance the magnetic field and cause the effects mentioned. This trouble was remedied by blowing the motor more frequently with compressed air.

Shefford, Bedfordshire, England. W. E. WARNER.



Conveyor belts in a coke oven plant of the Indiana Steel Company, Gary, Ind., each one driven by an individual electric motor

Electrical Equipment *for Coke Plants*

By R. F. EMERSON
Industrial Engineering Department
General Electric Company
Schenectady, N. Y.

MOTORS and control equipment for coke plants may be divided into four divisions according to their application, as follows:

(*a*) Coal Handling.
(*b*) Coke Handling.
(*c*) Operations at the Coke Ovens.
(*d*) By-Product Processes.

Operating conditions as well as external conditions of heat, dust, and acid fumes vary for each of the above divisions. As far as exclusion of external dust and fumes is concerned, totally inclosed motors which are absolutely tight would meet all conditions, but this expedient is not considered necessary or feasible in all cases. Conditions as they exist in each of these four divisions, together with recommendations for meeting these conditions, will be discussed separately.

Coal Handling — Coal is usually brought to coke plants in cars or barges, which are sometimes emptied by means of coal bridges. Open type, intermittent-rated motors, either a.c. or d.c., with full magnetic control are recommended for this work, on account of the fast duty cycle under which the equipment usually works. A duty cycle as fast as 20 sec. from the time the bucket leaves the coal pile until its return is not unusual.

When coal is received in cars, car dumpers can often be used to advantage. There are two types of dumpers used, depending on local condition, *viz.*—the cradle type and the rotary type. The cradle type is built in two designs, the "turn-over type" and the "lift and turn-over type," the latter being used where the coal must be elevated before being dumped.

On account of the large power requirements of the lift and turn-over type, and the accurate speed control required, Ward-Leonard control is justified and has been used with great success within the last year and a half.

The roll-over dumper is used where conditions will permit, on account of its lower cost and smaller power requirements. Either a.c. or d.c. drive with rheostatic control can be used. Both slip-ring and squirrel-

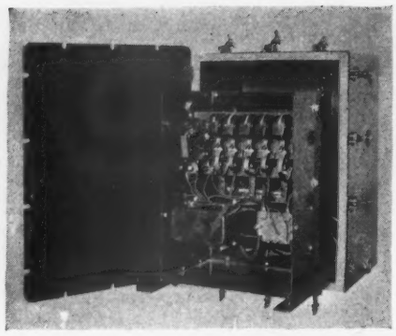
cage motors have been used successfully, including two-speed, high-torque, squirrel-cage motors. Two speeds are sometimes desirable; the high speed for turning the dumper, and low speed for accurately lining up the rails.

From the unloading house, coal is brought to the breakers and crushers by belt conveyors. The motors driving these conveyors are subjected to vast quantities of coal dust, but as a rule coal dust is not considered injurious to motor insulation. Open-type, squirrel-cage motors can be recommended for this application, but in ordering these motors, the motor manufacturer should be advised of the service so that extra treatments will be given the insulation if necessary. This extra precaution entails a small additional cost but it is well worth while. Since a conveyor requires high torque at starting, a squirrel-cage motor designed to give a high starting torque at zero speed and having good full-load efficiency should be used. A motor which will deliver 200 per cent of its full load torque at starting should be able to start its conveyor under the most adverse conditions of neglected or frozen lubrication.

The simplest method of control is to use across-the-line starters, with dust-tight inclosing cases and dust-tight push-button stations, provided the motors can be guaranteed for this method of starting. It is also necessary to get the conveyor builder to guarantee his equipment for this method of starting on account of the sudden shock to which the equipment is subjected.

* * * *

250-HP. INDUCTION MOTORS operating a hammer mill in a coke oven plant.



AN ACROSS-THE-LINE STARTER inclosed in a dust-tight boiler plate case specially designed to exclude abrasive grit such as coke dust.

* * * *

For the crushers, breakers, and hammer mills, the continuous-rated, slip-ring motor is used. Squirrel-cage motors are sometimes successfully used for these drives, but due to the time required in accelerating the load and the occasional necessity for breaking out a clogged machine from rest, the slip-ring type motor is preferable. The starting current of a squirrel-cage motor is relatively quite high and the heat generated during the starting period goes to heat up the copper in the motor. In the case of a slip-ring motor, this heat can be dissipated in the external resistance grids.

Coke Handling — Equipment for handling the coke is mainly belt conveyors and screening devices. The torque characteristics required of the motors are the same as for the motors previously discussed for driving the coal conveyors. That is, squirrel-cage motors with high torque at starting to break static friction are essential, and good full-load efficiency is desirable. However, the difference between coal dust and coke dust makes it imperative to use totally inclosed motors for the coke conveyors. Coke dust is abrasive and injurious to motor windings so that a totally inclosed motor, or an inclosed ventilated motor, or an inclosed fan-cooled motor is necessary when subjected to the amount of abrasive dust that a coke conveyor motor usually gets in a coke plant.

The inclosed ventilated motor is seldom used, first, because of the expense of long pipe lines required to reach some source of clean air, and secondly, because of the difficulty and expense of securing a source of air, free from abrasive dust in the vicinity of the coke operations.

The totally inclosed motor, although less expensive than the inclosed ventilated motor with its accessories, is considerably more expensive than the corresponding open motor of the same horsepower rating because it must be built in a frame several sizes larger than the corresponding open frame motor. This is due to the increased heating of the inclosed motor. This type of motor has been recommended and is now being used with success for coke conveyor drive, but its use will doubtless decrease in future installations due to the advent of the inclosed fan-cooled motor.

The inclosed fan-cooled motor is a comparatively new advance in the art of protecting motor windings from abrasive dust, but sufficient installations have been made in coke plants subjected to coke dust and in automobile plants where the motors are deluged with metal filings, to demonstrate its worth. This motor is built in practically the same frame size as its corresponding open-type motor.

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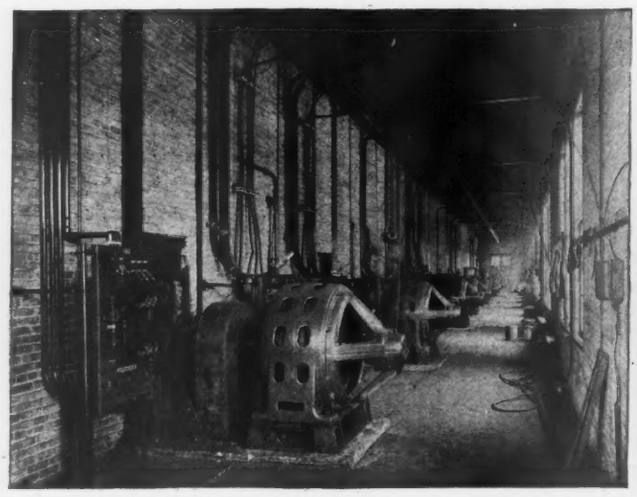
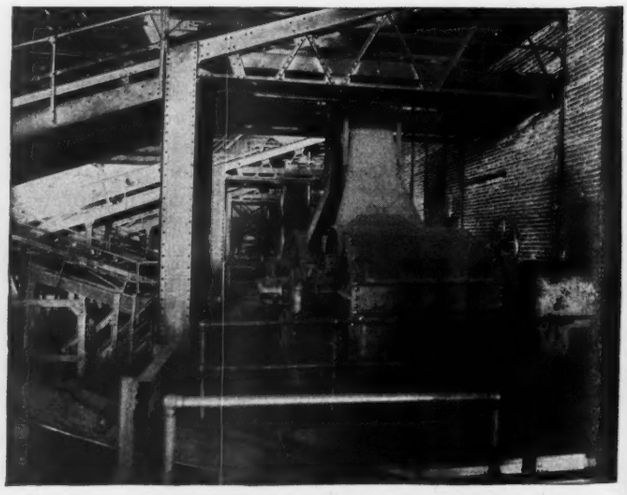
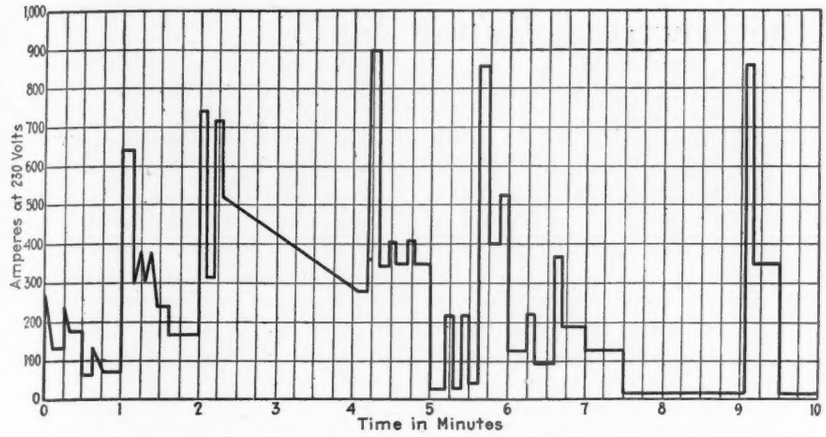
HAMMER MILLS in a coke oven plant driven by 750-hp. induction motors.







LOAD DIAGRAM to determine the size of a synchronous motor generator set to furnish power to d.c. motors used for coke oven operations.

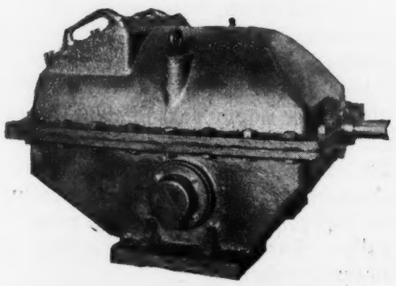
This means a less bulky motor than would be the case if the fan cooling feature were omitted and, therefore, a less expensive machine. This motor has an inner and outer shell. The inner shell excludes all dust from reaching the motor windings, and absorbs heat from the windings. This heat is effectively radiated by the agitation of the internal air at both ends, by the internal rotor fans, while other fans installed between the inner and outer shell draw air from the outside causing it to flow over the inner shell, thus, effectively dissipating the heat. The inner shell prevents dust from getting into the interior of the motor. The circulation of air between the two shells is sufficiently rapid to prevent any accumulation of foreign matter in the air ducts. These motors have rotors interchangeable with open motors of corresponding ratings and are equipped with ball bearings.

As in the case of coal handling, dust-tight, across-the-line starters with dust-tight push-button stations can be used to advantage. The dust-tight feature is, of course, even more essential in coke handling than for coal handling.

Operations at the Coke Ovens—For the coke oven machines such as the pusher ram, leveler bar, charging machine, door machine and quenching locomotive, both d.c. and a.c. machines are in successful operation at various plants.

* * * *

AN INDUCTION MOTOR embodying the wide flange construction of the type approved by the Underwriters' Laboratories for use in explosive atmosphere.



On account of the heavy torque duty required by these machines, the well known characteristics of the series motor make them peculiarly adaptable, and a large proportion of coke plants have motor-generator sets to convert the power from a.c. to d.c., and use totally-inclosed, intermittent-rated, d.c. series motors on all of the above mentioned oven operations. The pusher ram and charging machine being subjected to a certain amount of external heat from the coke oven, should have fire resisting insulation complying with Class *B* insulating materials, in accordance with Standardization Rules A.I.E.E., November, 1918.

Usually, two motor-generator sets are used, either one of which can handle the load at the ovens. One set serves as a spare. Since the oven load is very fluctuating, the size of the sets is determined by the commutating ability of the d.c. generators.

A large number of the smaller plants use totally-inclosed, intermittent-rated, slip-ring induction motors for these operations. The control of the speed, however, is not as good as can be obtained with d.c. motors. Also, the induction motor is limited in torque, for which reason a larger motor is required than would be the case if a d.c. motor is used for the pusher ram operation. Some kinds of coal tend to expand during the coking process, and although the oven walls diverge toward the discharge opening, the coke may tend to stick, calling for high starting torque on the part of the ram motor. For this reason, an a.c. motor for a given ram should be larger than would be the case if a d.c. series motor were used.

By-Product Processes—The volatile products from the distillation of bituminous coal include benzol, sulphate of ammonia, sodium cyanide, carbolic acid, and various coal tar products. As a result, sulphur fumes are present in the atmosphere, and its effects can be seen by the discoloration of any exposed copper parts, such as bus bars.

The pumps and conveyors used in the by-product processes can be driven by constant-speed, squirrel-cage motors, but in some plants, some equipment is steam driven due to the danger of explosions. The whole question of suitable motors for such conditions is relative and depends on how much gas is present and how disastrous an explosion might prove. Conditions might be such that an open-type motor with special insulation to resist strong acid vapors is all that is required. For extreme conditions, switches should be oil immersed or mounted outside the building. For small motors up to 15 hp. 1,800 r.p.m. totally inclosed machines approved by the Underwriters Laboratories can be used. For larger units, inclosed fan-cooled motors with the cooling principle as explained under "Coke Handling" can be used, but these motors should be built according to Bureau of Mines Standards. It should be understood that none of these motors are gas tight so as to exclude the explosive gas. However, the safety feature is obtained by using a large number of bolts and wide flanged joints accurately machined. In event of an explosion inside the case, the flame is sufficiently cooled before it reaches the outside atmosphere. Incidentally, this type of motor is being used with much success in the oil fields.

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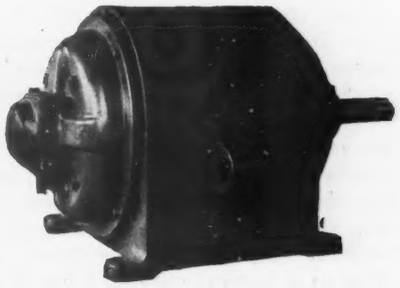
THIS MOTOR has a double shell and fans so the cooling air is drawn between the two shells. This permits the use of a smaller and cheaper motor for a given horsepower rate than with ordinary construction.



Layout of the Electrical Repair Shop

(Continued from Page 293)

After the dead cut-off coils have been removed the rewinding operation begins. If spare coils are not available from stock where various types are always kept in reserve, they are made up as needed from data obtained from similar motors. However, if this equipment was the first of its type to come to the shop for repairs the inspection report would correct this condition.

In this connection, a Rating and Parts Data Repair Record, shown in an accompanying illustration, would be used to carry all information as to rating, parts, winding data, manufacturer's catalog numbers if obtainable, and all pertinent data necessary for the repair of the equipment. Such sketches would be drawn as were necessary to assist them in making coils and the connections. This record, therefore, constitutes a complete detailed description of the equipment and it is kept on file in the shop for future reference. It simplifies the repair procedure when the equipment again appears in the shop.

Having this information, the actual rewinding begins, but inasmuch as it is an ordinary procedure that is common to all repair shops and accomplished with as few motions as possible no further description will be made. When the coils have been placed in the slots, but before being connected, they are tested first for grounds, also cross connections in armature. If this test shows that the condition is good, the connections are then made, soldered and taped where necessary and a second test is given which includes a high-potential test. If the voltage required is over 500 volts this is accomplished by means of a portable 6,600-volt transformer that has been rewound with the secondary taps brought out for voltages ranging from 500 to 5,600 volts. However, if it is necessary to stay below that value, potential is obtained from a 1-kw. motor-generator set driven from the shop circuit.

In order to locate grounds or other faults, armatures are tested on a growler which was built in the shop. It is portable so that it can be moved to any section of the shop where needed and adjustable so that it can be placed against the armature on any size stand. The core is set in a vertical sliding frame so that it is kept in a vertical position when it is being raised or lowered by means of a built-in winch set in the head frame. A Trumbull safety switch controlling the circuit is attached to the rear of the growler core and moves with it in the frame.

A Century armature tester is then used on the armature to locate open or shorted coils. After passing all tests, preparation is made for the banding operation, which is done in the lathe instead of using a special banding machine. Considerable trouble has been eliminated with the use of bronze wire for this purpose, especially with large d.c. armatures in which excessive heating caused the solder that held the banding clips in place to melt, thereby permitting the bands to be thrown and consequently causing considerable damage to the coils that were thrown out of the slots by centrifugal force. A special hard solder that is purchased from the National Lead Company is now used to keep the bands in place.

If the equipment passes all these subsequent tests satisfactorily, it is sent to the oven to bake out any dampness that it may have accumulated and is kept there until heated to 85 or 95 deg. C. throughout. It is then removed from the oven and taken to the dipping tank located beneath the floor where it is submerged in black baking varnish and left there until the air bubbles cease. (Transformer coils are treated in practically the same manner except that they are dipped in clear oil-proof varnish.) It is then suspended above the tank to drip for a few hours before it is again taken to the oven where it is thoroughly baked for about 36 hr. at the same temperature heretofore mentioned.

No further dipping or baking is done in this shop unless it is a special job. This procedure has been found to be very effective; of course, the varnish is full strength when used.

New bearings are fitted to the shaft when the baking operation has been completed if the inspection report shows that they are necessary. The gage test that was made before the motor was torn down insures them of this necessity for supplying bearings. However, if there is any doubt, a new set of bearings will be furnished. Spare bearings are being made up constantly by one man, but for most induction motors in the rough and when needed they are drawn from stock, bored and scraped to fit as closely as possible.

As soon as the bearings are fitted the motor is assembled and subjected to another gage test to insure the correctness of the bearings and the clearance in the stator. Oil is then applied to the bearings and the motor is carried by the crane for final testing to the main test board which consists of two panels taking service from the three-phase 440-volt, a.c. and 250-volt d.c. power circuits furnished to the shop. Here facilities are provided for prony brake tests on motors to insure satisfactory performance when they are sent back in service. Direct-current motors are connected to an E. C. & M. controller that is located to the rear of the panel at the left as shown in the illustration. Connections for armature and field circuits of shunt, series or compound motors are made by means of the inclosed switches and line leads with clips. The controller in the center is used in testing slip-ring motors up to 100 hp. in capacity whereas, squirrel-cage motors up to 25 hp. in size are controlled from the hand-starting compensator at the right.

As the equipment is cleared by means of successive tests and examinations during its period of overhauling, the work order is also completed. The cost of supplies has been entered as well as the labor, thereby fulfilling the request for the accrued cost. This work order is then approved by the electrical repair shop foreman, who guarantees that the equipment is in first class condition and available for service. The work order bearing the accrued cost is forwarded to the electrical maintenance superintendent for his records, also a copy is sent to the cost department where the record is kept of all machinery repair costs from the time that it is purchased until it is scrapped.

Not all work, however, is done in the electrical repair shop, but the procedure followed is identical with the repair shop methods. An emergency may occur in any part of the mill such as occurred on a 2,000-hp. job mill motor as shown on page 273. In such cases, depending on the importance of the job, the repair shop men are called into the plant to effect the necessary repairs.

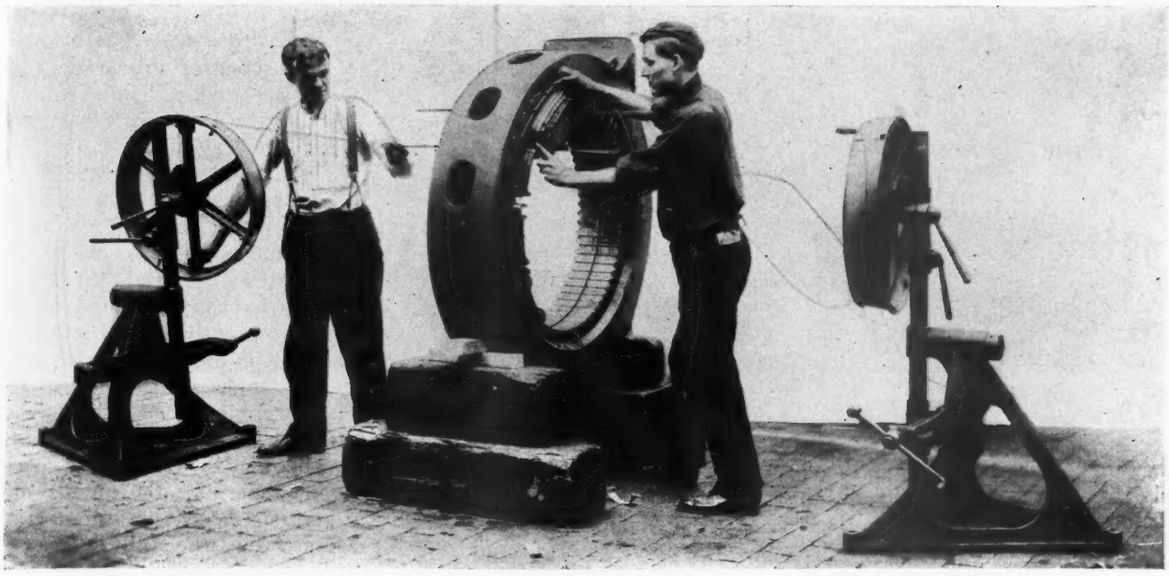


Fig. 1—Start of a concentric-chain type, two-range, hand winding.

Bringing Obsolete Motor Windings *Up to Date*

By A. C. ROE

Renewal Parts Engineering Dept., Westinghouse Electric & Manufacturing Company

THERE are in daily use in all parts of the world a large number of Westinghouse alternating-current generators and motors of obsolete design, and we are constantly receiving orders for spare or renewal stator coils for them.

The majority of these old-timers have many years of useful life ahead of them, and to replace them with modern equipment would, in a large number of cases, not only be difficult to justify, but would entail considerable expense, particularly when replacement means scrapping the prime mover, switchboard, control, and so on.

In these cases it is, therefore, much more economical to rewind the stator with new coils of up-to-date design, developed from factory records and test data.

The reason for prescribing up-to-date windings and coils is that all of the old, obsolete machines had stator windings that are not used in American practice today, as modern machines are wound with coils of the two-coil-per-slot, two-layer, or diamond-shaped pulled types or formed coils. The pulled coil is used up to its practical limits, formers being used for the large, two-pole turbo coils, or when the coil is large and hard to shape.

The stator windings used in the older machines were all of the one-coil-per-slot type. The arrangement of the end windings on either side of the core, type of conductor used, and voltage and size of the machine were the factors governing the type of winding used.

The types of windings were divided as follows:

1. Hand winding, concentric chain type, the coil ends being straight or bent. (Details of construction will be given later).
2. Concentric chain winding, shove-through type, the coils being formed of wire, ribbon, or strap conductors, for use in partly-closed slots.
3. Open-slot concentric chain windings, with straight or bent coils.
4. Open-slot, two-layer, diamond-shaped coils with a double drop at the ends of the bottom cell.
5. Open-slot involute coil ends.
6. Open-slot combined involute short and diamond-end type.
7. Bar and end-connector type.

All of these old types of windings are difficult and expensive to install, requiring considerable taping, shaping and blocking.

The construction of the coils is also expensive, as they are all mold-wound or shaped on a former. In some cases these molds or formers have been scrapped, or have deteriorated so much that a new former or mold must be made. Furthermore, for some types of coils anywhere from one to eight different-sized molds must be made to manufacture one set, or in some cases only part of a set, of coils.

Not only are these old coils more expensive, but they are also inferior in many respects to the modern coils

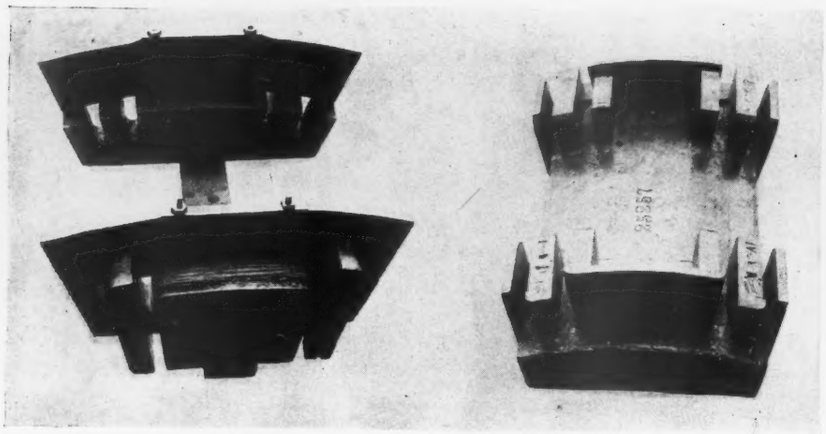


FIG. 3—FORMING blocks for concentric-chain type hand winding. The block at the left is for shaping bent coils; straight coils are formed on the block at the right.

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in that they have sharp and intricate bends that are extremely difficult to insulate properly. Again, when there are a large number of turns in series per coil, and the coil is built up in sections, the difference of potential between sections is quite high in some cases.

Most of these old types of windings can be replaced with up-to-date types of coils that will not only be cheaper to make and install, but will improve the performance of the machine in the following respects:

(*a*) In most cases the total length of copper per coil is reduced by changing the type and shape of the end connections and reducing their length by using fractional or chorded pitch, thus reducing the copper losses and inductance, and improving the efficiency.

(*b*) The wave shape is improved in some cases by chording the winding and the overlapping of the phase belts. Chording the coil pitch on large machines also reduces the self-inductance of the winding, as the inductance of the coil ends is reduced by the shorter coil end connections.

Chorded-pitch, one-coil-per-slot windings were seldom employed, due to the fact that in parts of the winding the phases alternate with one another; that is, adjacent slots are not of the same phase.

(*c*) Where a solid conductor of large cross-section had been used in the original winding, the new conductor would be broken up into smaller strands, reducing eddy losses and skin effect. (Skin effect is a term indicating that the resistance of a conductor, carrying alternating current is increased, as compared with its resistance when carrying direct current. The increased resistance is due to the fact that alternating current seeks the outside of the conductor. Skin effect depends on the permeability of the copper, its cross-sectional area, and the frequency. It is greater on higher frequencies and with large cross-sectional area.)

(*d*) The cross-sectional area of the new winding conductor can be increased in some cases, thus reducing losses and increasing capacity and efficiency.

The above points can be explained better by considering each type of winding separately and describing the constructional details of the old-type winding and what can be accomplished with a new type of winding.

This series of articles will, therefore, be divided into groups to describe the types of windings mentioned above.

Hand windings were the first type used, and the coil ends were arranged in such a manner as to give them the appearance of a link chain; as one coil nested inside the other, the term concentric chain winding was applied to this type (see Figs. 1 and 6.) The coil ends in most cases were arranged in two ranges; that is, half of the coil ends were bent and the other half straight, as shown in Fig. 2.

The number of coils per concentric group determine the number of different-sized coils required per machine; thus the full description of this type of winding would be: concentric chain winding, two ranges, two straight and two bent coils.

Fig. 1 shows a concentric chain hand winding with a few coils in place and one coil being built up by hand; this winding has two bent and two straight coils in two ranges. In this illustration note the forming block, reels and stands, and the pins projecting from the slots.

The method of winding is to fill the two slots into which the coil is to be wound, with wooden or wire pins, the same diameter as the wire used for the coil. One of these pins is pushed out when one turn of the coil is passed through the slot; this pro-

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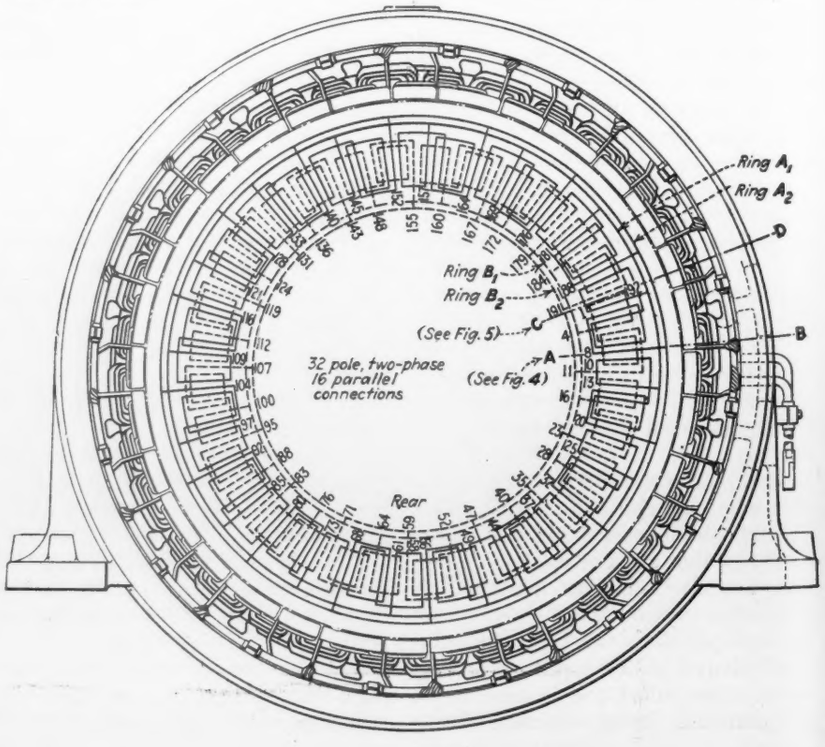
FIG. 2—ARRANGEMENT of hand-wound winding in old, two-phase alternator. There are 64 groups with a total of 96 coils, connected 16-parallel for 220 volts.



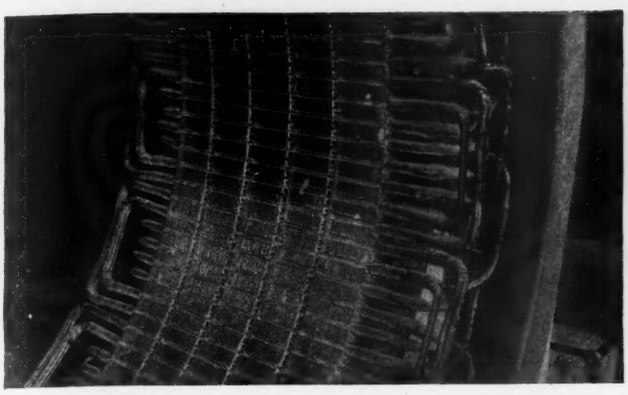


FIG. 6—CLOSE-UP of concentric chain winding. Note that the bent coils, which are visible at the right, cannot be seen at the left as they have been bent back out of sight.

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cedure maintains the wires in proper formation in the slot sections.

On each end the wire is formed across special blocks cut to the shape shown in Fig. 3. The block at the left is for the bent coils and is the one in place in the stator shown in Fig. 1. The block at the right is used to form the straight coils.

The bent coils are wound into place first, and then the straight coils are wound into the slots left vacant between the sides of the bent coils.

The term bent coil (see Fig. 4) is used to denote a coil that has its ends bent up at a 90-deg. angle from the slot section. The term straight coil (Fig. 4) denotes one in which the ends are formed straight out, only enough radius being put in the coil ends to clear the bore of the stator iron.

The slots of these old machines were of the partly closed type and the slot cells, or winding cells, were made up into a tube which was pushed into the slots. The winding was threaded through these insulating tubes, one turn at a time.

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FIG. 8—MUSH PULLED coil in shuttle form, before it is pulled to the shape shown in Fig. 9.

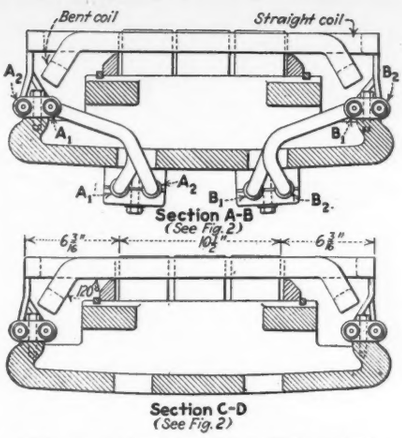

FIG. 4—(*Above*)—HOW THE LEADS were brought out on the old alternator. A bent coil is shown at the left and a straight coil at the right. Fig. 5—(*Below*)—The over-all length of the old alternator winding, with the projections on each side of the core.

* * * *

It is evident that to rewind a machine of this type, with the same type of winding, would be a long and expensive job. However, this type of winding can be redesigned to make it more modern and less expensive, as will be shown later.

Another item that adds to the expense of the hand winding is that all coil ends must be taped by hand with tape that is cut into lengths; due to the confined space and shape of the coil ends, these pieces of tape are awkward to handle and apply.

An example will best illustrate the

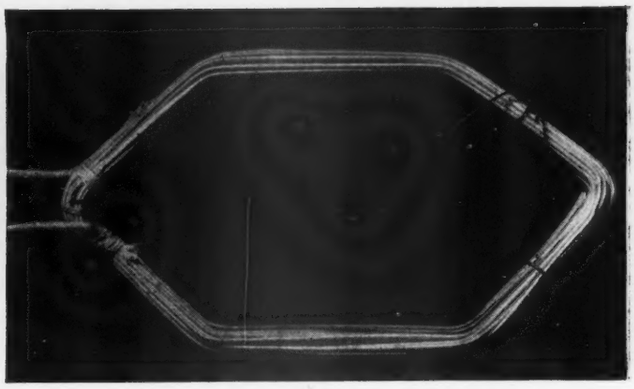

FIG. 7—FLAT DIAMOND mush coil with sleeves on the leads, which have been tied.

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application of the points mentioned above.

The machine in question was a 175-kw., two-phase, 220-volt, revolving-field a.c. generator, 198 amp. per terminal, 32 poles, 225 r.p.m. It had 192 slots, 96 coils, hand wound as in Fig. 1, each coil consisting of 19 turns of one No. 9 (0.114 in.) d.c.c. wire. The winding was connected 16-parallel, as shown in Fig. 2.

The bore of the stator iron was $56\frac{1}{2}$ in., and the length of the core $10\frac{1}{2}$ in. The slots were $1\frac{29}{64}$ in. deep by $\frac{29}{64}$ in. wide with a $\frac{1}{8}$-in. opening at the top.

The winding was arranged as shown in Fig. 2, having a total of 64 groups, or 32 groups of two coils per group, and 32 groups of one coil per group, or 96 coils in all. There were four different-sized coils requiring the two hand-forming blocks shown in Fig. 3.

The winder would first form the 32 short or inside bent coils and then the 16 long or outside bent coils. The next step was to install the 32 short, straight coils and then the 16 long, straight coils, the coils being wound so that one phase would have all the

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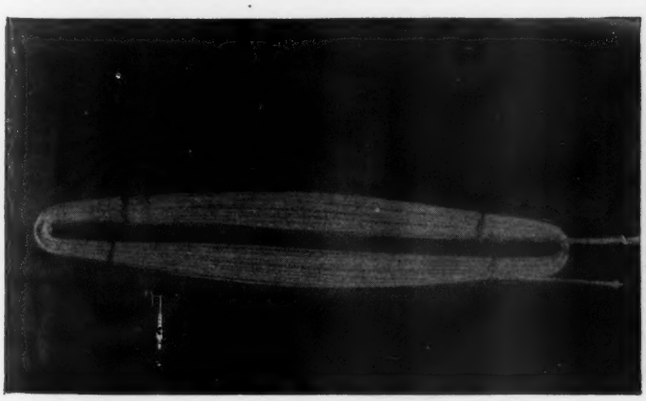
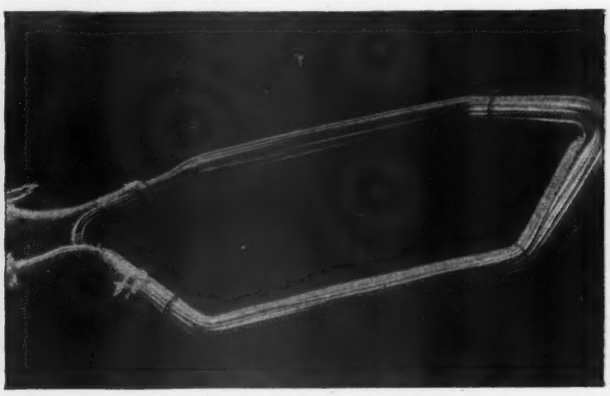
FIG. 9—MUSH PULLED coil after pulling to shape, with the leads tied.





leads of its coils on one side of the machine and the leads of the other phase on the opposite side, as shown in Figs. 4 and 5.

Fig. 4 shows how the leads were brought out, and Fig. 5 shows the over-all length of the winding and the projection on each side of the core.

Fig. 6 shows a close-up of a concentric chain winding, showing how the straight coils stand out at the left and the bent coils drop out of view.

The pitch of the coils for the above winding was 1 and 7, and 2 and 6, that is, the outside coil was 1 and 7 and the inside coils 1 and 5. This represents $6 + 4 \div 2 = 5$, or an average pitch of 1 and 6.

The problem was to develop a winding that would allow the use of a mush pulled coil and the two-layer, diamond-type, threaded-in winding, which is the best type to substitute for hand windings up to and including 600-volt service.

Considering the new winding, No. 9 d.c.c. wire was too large to feed through the slot opening, and also too heavy to use in a mush-wound coil. It is hard to shape and more likely to develop short circuits from the pounding required to make the coils fit into place.

The old winding had 96 coils, one per slot; the new winding would have 192 coils or two per slot; thus the turns per coil would have to be reduced one-half, as the number of coils per group or per phase would be doubled.

Then $19 \div 2 = 9\frac{1}{2}$ turns per coil, or say 10 turns, but to make the turns per coil as low as possible, a five-turn coil could be used and the connection changed to eight-parallel, which would result in the same line voltage.

Or the turns per phase for the new winding can be worked out as follows: The old winding had 96 coils, 19 turns per coil, and the winding was connected 16-parallel for 220 volts. Then, the turns per phase equal $96 \div 2 \times 19 = 912$ turns, and with a series connection the volts per phase would be $16 \times 220 = 3{,}520$ volts.

Reducing the turns per phase one-half, or $912 \div 2 = 456$ turns, would give $3{,}500 \div 2 = 1{,}760$ volts per phase. Then as $1{,}760 \div 220 = 8$, an 8-parallel connection would be suitable for 220 volts.

As the new winding would have two coils per slot, or the same number of coils as slots, the number of coils per phase would equal $192 \div 2 = 96$ coils per phase, and with 456 turns per phase and 96 coils per phase, the turns per coil equal $456 \div$

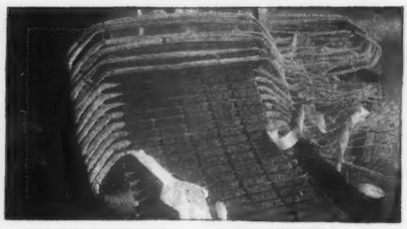


FIG. 10—METHOD of taping coil ends on flat mush or mush puller coils.

* * * *

96 or 4.75 turns per coil. Using five turns per coil we have $96 \times 5 = 480$ turns per phase, which is only 5 per cent higher than required, and the coil pitch can be reduced one slot to offset the slight increase in turns.

As mentioned above, the average coil pitch of the old winding was 1 and 6; thus, dropping one slot makes the new winding coil pitch 1 and 5.

The turns per coil were reduced in this case in order to lower the cost of the coils, as five turns can be made in a shorter time than ten turns.

Next, the size of wire was determined as follows: No. 9 wire has a bare diameter of 0.114 in. and an area of 13,090 circ.mil. As the connection was changed from 16- to 8-parallel and the turns reduced one-half, it follows that the cross-section area must be doubled, or $13{,}090 \times 2 = 26{,}180$ circ.mil are required.

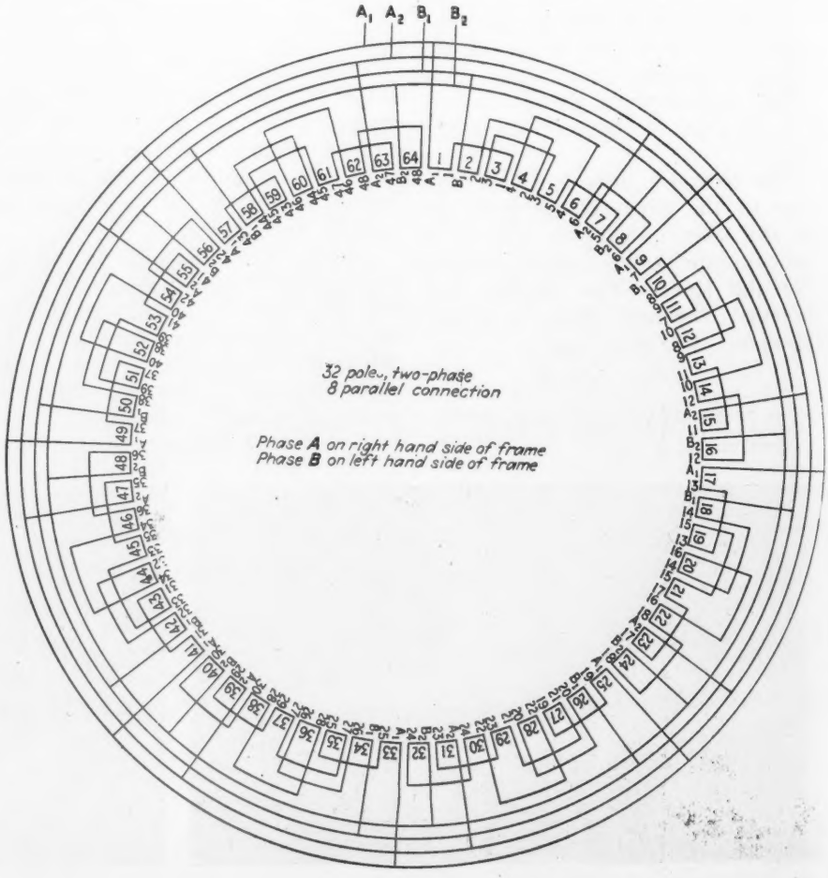
As No. 15 or smaller wire is more suitable for mush or promiscuous windings, we will try No. 15 first. One No. 15 has an area of 3,257 circ. mil; then $26{,}180 \div 3{,}257 = 8$, approximately, or eight No. 15 single-cotton and enameled wires in parallel can be used.

There are two types of mush coils that could be used: The first is the flat diamond mush, shown in Fig. 7. This is the simpler to make, but when the turns per coil and number of wires in parallel per conductor result in a coil having a cross-section of $\frac{3}{8}$ in. square, or more, the flat mush coil requires more time for shaping the coil ends while winding the stator; this offsets the somewhat longer time required to make a pulled coil.

The second type is the mush pulled coil, shown in Figs. 8 and 9. Fig. 8 shows this coil as it is removed from the shuttle, before pulling to shape; note the tape on the leads. Fig. 9 shows the coil pulled to its final shape, with the leads tied to the coil. Note the shape of the ends, which results in a two-layer, diamond-end winding, requiring very little shaping.

* * * *

FIG. 11—NEW WINDING developed for old alternator. There are 64 groups, three coils in series per pole phase group, connected 8-parallel.



All mush coil windings for changes of this nature should have the coil ends taped as follows: Tape all coil ends and run the tape well into the slot; then tape the ends of the slot sections, sealing the ends of the winding cell as shown in Fig. 10.

The slot cells are 0.023-in. fish-paper or combination slot insulation bent to fit the slot.

A layer of treated duck is used between the end windings, and a fiber strip placed between the top and bottom coil halves in the slot section; this strip should extend past the end of the longest slot portion of the coil.

A fiber wedge should be used in the top of the slot and any excess room taken up with fiber or wood fillers, placed either at the bottom of the slot or under the wedge. In all cases pack the slot tight.

Where practicable dip and bake all mush coil windings, using a good, plastic baking varnish, and allow it to soak well into the slot sections.

Mush windings can be used for voltages up to and including 2,400 volts, but the coils must be wound carefully and kept as close to the layer-wound type as possible, using in all cases double-cotton and enameled wire. The coils should be well treated in high-grade, black varnish.

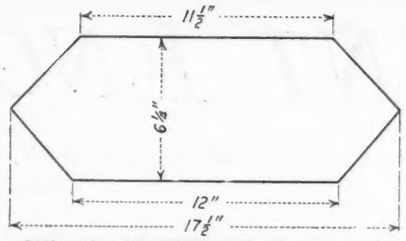


FIG. 12—DIMENSIONS of new mush pulled coils that replaced hand winding in alternator. The new winding was 86 lb. lighter than the old one.

* * * *

The slot cells should be made from mica with additional insulating material around each coil half and a fiber or Micarta separater between the coils in the slot.

The ends of all coils should be taped with treated-cloth tape and cotton tape applied as in Fig. 10.

The new winding as developed consisted of 192 mush pulled coils, Figs. 8 and 9, each consisting of five turns of eight No. 15 s.c.c. and enameled wires in parallel per conductor, coil pitch 1 and 5. There were 64 groups, three coils in series per pole phase group, connected 8-parallel, as shown in Fig. 11, with the coil ends taped as in Fig. 10.

The original winding had the phases connected on each side of the machine; so the new winding had 96 right-hand coils and 96 left-hand coils, the coils being wound and pulled so that half the set had the leads on the opposite side. In winding the stator a group of three left-hand coils would be put in, then a group of three right-hand coils, and so on.

Figure 12 shows the size of the coil. The complete set weighed 264 lb., whereas the old hand winding required 350 lb. of copper; so the new winding was 86 lb. lighter.

The above change indicates what can be done with the lower voltage windings. Old hand windings designed for more than 2,400 volts can be changed over, but it means that the slot opening must be increased. This should be done only after a thorough check of the test curves and design data to determine the effect on the motor or generator performance.

Adapting Gantry to Charging Annealing Oven

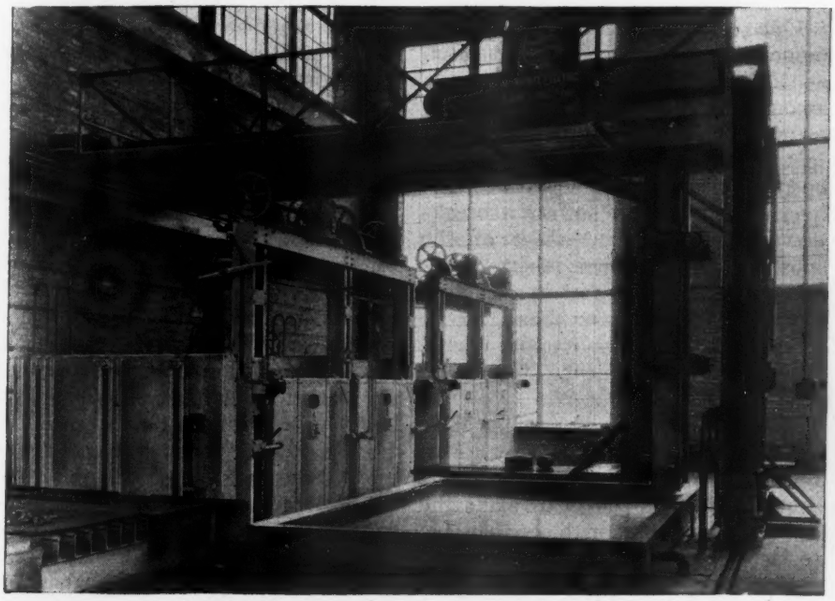
AN UNUSUAL adaptation of a crane for the handling of castings in and out of annealing ovens and quenching tanks is shown in the accompanying illustration. This installation was made in the plant of a middle-western builder of heavy machinery and has effected a substantial reduction in handling costs, it is reported.

The equipment consists of a 2-ton, single-leg gantry bridge crane which carries a charging trolley of special design.

When the oven door is open the castings are deposited on a stationary rail on the floor of the oven, quite similar to the loading rack. The charging trolley is operated in the reverse direction until the prongs are withdrawn and the door is closed by operating a second push-button at the control station.

Castings to be annealed are placed on the loading rack, which is located at the left of the ovens in the accompanying illustration. These racks are constructed of 8-in. rails spaced 8 in. apart and of a length corresponding to the length of the charging prongs. The gantry travels until the prongs are in line with the openings between the rails. The trolley is then racked forward to insert the prongs under the castings.

The charge is then raised clear of the loading rack and carried by the gantry to a position opposite the annealing oven. The oven doors are electrically operated by the operator the load withdrawn until over the quenching tank, which is located directly in front of the ovens. The hot charge is lowered into the tank and the trolley moved backward and forward to remove scale and aid in obtained more uniform cooling. The crane installation was made by the Milwaukee Electric & Manufacturing Company, Milwaukee, Wis.



* * * *

SINGLE-LEG GANTRY CRANE arranged for charging annealing ovens and quenching castings.

The PLANT ENGINEER'S

Conducted by F. M. GIBSON, *Consulting Editor*
Plant Engineer at American Sugar Refining Company

ONE of the most helpful organizations that it has been my good fortune to join owed much of its success to informality. Such informality does not necessarily mean loss of dignity or lack of self-respect. To be informal is to be natural. It not only results in greater freedom of expression but it is the quickest means of appraising true worth. To be of real value, this Forum must have these qualities. For that reason, the editorial "we" on my part will be omitted.

There is at the present time much dissatisfaction with terms that have been outgrown in the rapid engineering progress of recent years. One excellent example of this is the title of the engineer in charge of the engineering department of one or several industrial plants. Such an individual today is called by various titles—master mechanic, chief engineer, mechanical superintendent, plant engineer.

It seems to me that a term far more accurate and less likely to be misinterpreted would be Industrial Engineer. It is true that this term has been used by some engineers to replace that of Efficiency Engineer, when the latter became malodorous. Also, it has been appropriated by certain accountants. These, however, are obvious misapplications, and will probably be of short duration. The term Industrial Engineer, applied to engineers in charge of the engineering department in industrial plants is fundamentally correct and would therefore be permanent. What do you think about it?

A rural doctor decided to practice in the big city. Walking around in the district where he intended to settle down, he noticed by the signs on other doctors' offices that each one was a specialist of one sort or another. Himself being a general practitioner, he met the situation by hanging out his shingle as "General Specialist."

The industrial engineer might well place himself in the same category. Not only must he have a thorough knowledge of all equipment, production methods and service, but of all the processes and steps in production in his own type of industry.

Much has been said of the value of the engineering mind, especially of its analytical and logical characteristics. The industrial engineer especially needs that type of mind at the present time. Some industries, while maintaining a normal production, have had small profits and are not in a position to invest large sums in improvements which require a long time to yield anticipated returns on the investment. Money for improvements, in such cases, must be spent in smaller amounts and where it will yield the largest and most immediate results. It is up to us to think along these lines.

One of the methods of finding money for improvements, and often at slight expense, is by reducing the amount of material in process of manufacture. One department in a factory will sometimes have to stop operations because the department delivering goods to it suffers a breakdown. The superintendent of the subsequent department then, being human, insists thereafter upon having plenty of material on hand at all times to insure uninterrupted operation of his department. Generally, he carries too much stock.

The industrial engineer fits into this picture because, in most cases, the condition is due to unreliable equipment. His job is to make the equipment reliable, or to see that it is replaced. In one case that came to my knowledge, the result of this procedure was a 40 per cent reduction in the amount of money invested in idle stock. Another method of accomplishing similar results is by substituting continuous flow of materials for the batch system. Often, the savings are far-reaching; in labor, power, excess cost of handling, and even in the cost of heat to maintain material in condition in storage.

The labor-saving accomplishments of automatic machinery and mechanical conveying, loading and unloading equipment are becoming better known; but they are not being taken advantage of as they should be. A large part of the responsibility for this lies at the door of the industrial engineer. It is primarily his job to study conditions in his own plant and to keep abreast—or a little ahead—of developments in similar plants.

In the case of mechanical handling equipment, installation costs are moderate, the equipment can be installed in a short time, and returns upon the investment are immediate. For instance, where you have four men loading cases upon a truck or conveyor, suppose you substitute a hoist with two men, one operating the hoist and the other hooking on. The hoist costs $1,200 installed, and the annual wage cost of the two men it replaces is about $2,200.

In addition to the direct labor savings and the greater handling efficiency, another major managerial problem is involved. In some localities it is difficult to secure operatives for the night shift, and any reduction in the number of operatives on these shifts is an aid in solving the labor problem. The handling of heavy loads requires men of strong physique, and the market is not always flooded with labor of this kind.

Until a few years ago sugar refineries were dependent upon this type of labor to unload centrifugal machines. Scarcity of men of the requisite strength led to the invention of a mechanical unloader that in-

Forum

creased the speed of unloading and made possible the employment of a less husky and probably more intelligent type of employee.

Recently, we lost a motor that had been purchased not so long ago, and had no spare for it. Another motor was ordered from stock; but while it had the same characteristics, its overall dimensions were different and more time was lost in providing a new foundation. Some move should be made to induce motor manufacturers to adopt standard overall dimensions and to stick to them. The experience cited above is not unique; in fact, like the victims of a well-advertised disease, probably four out of five of you could tell similar stories. And I wish you would—sending them in for presentation in these pages. Then, perhaps, the motor manufacturers would sit up and take notice.

To many of the older men in our profession the electrical side of the industrial engineer's responsibilities makes for increased difficulties. The constantly growing application of electrical equipment and the advance in electrical engineering have correspondingly increased the need for greater technical knowledge on our part.

The generation of power is only one-half of the power problem; transmission and application of power constitute the other half. Review the papers of our national societies and our publications, and you will find comparatively few discussions devoted to the second half of this problem. Yet I know of no other branch of our responsibilities in a more chaotic state in industry today than the balancing of motor load with generating capacity, or of power load with heating load.

Some concerns have electrified their plants by gradual steps; adding installed motor capacity, then adding generating capacity and then adding synchronous motors to correct power factor—until the electrical system has become a heterogeneous mass of equipment.

Some plants electrified completely, a few years ago, with what seemed at the time plenty of generating equipment. In many cases, during these few years, replacement of labor by motor-driven equipment has greatly increased the power load; chemical processes have become more efficient in heat requirements, but in general the improvements have been accompanied by additional power requirements for conveying, pumping or mixing. In short, the heat balance in many of these plants has been destroyed because of the smaller heat load and greater power load.

Some of us are doing something about it; all of us need to know whether, in our own plants, something ought to be done about it.

Tom Farrell relates this experience. He had a motor-driven centrifugal pump that was installed with insufficient suction head.

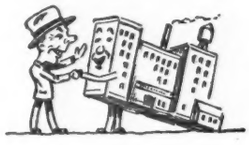
The production department found that by reducing the number of vats feeding the suction tank, to three, the latter did not overflow so often. Farrell lowered the pump two feet, and cured the trouble.

The station man operating the vats was still skeptical and would not venture more than three vats. This was explained to the supervisor of production and he, instead of investigating, took the station man's statement that only three vats could be run, and put in a request for a larger pump.

One of Farrell's assistants told the station man that the man on the other shift could run five vats. Thus bluffed the skeptical one went one better, and found he could run six vats! Not only was the requisition for a new pump not granted, but the management learned what a good many of us know—that the engineering department rescues many a production department from the consequences of its own mistakes.

Incidentally, the suction head on this pump as originally installed was sufficient for water, but not for a liquid loaded with air bubbles; which shows that by no means all useful engineering knowledge is contained in handbooks.

Constructive and executive ability on the part of the industrial engineer does not always go unnoticed and it is sometimes used by the management in other departments. Henry Tocks developed a system of routing repair and maintenance jobs that was so successful as to attract the attention of the management. Up to that time no satisfactory system of scheduling production in the various departments had been found. He was given the problem and, after one year's operation of the system, which he developed, the sales manager in their annual convention congratulated the factory upon its success in making shipments on scheduled time.



IN launching this Forum, you will note that I have taken all of the space to air some of my own views. You may agree with them, or not. You may—in fact, I know you must—have views on a variety of subjects in addition to those touched on here.

The whole purpose of these pages is to provide a place for the airing of views and a discussion and exchange of ideas. If we could meet informally, once a month, and "talk shop," we would all benefit. As the next best thing, we can meet here. This is no one-man job, and I want all the help you can give me. Address your letters to me in care of *Industrial Engineering*, 475 Tenth Avenue, New York, N. Y.

QUESTIONS *Asked and Answered* *By Readers*

HERE IS A PLACE *where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience*

Changing Repulsion Motor for Split-Phase Operation

I have a Wagner ½-hp., Type 8W5BA, 110 220-volt, single-phase, repulsion-induction motor that has been burned out and the commutator destroyed. I wish to convert it into a split-phase motor. The stator is 5¼ in. in diameter and 2 in. wide. It has 36 slots and was originally wound for four poles, the coils containing 40 turns of No. 16 wire, with two empty slots in the center of each pole. I want to use these empty slots for the starting winding. I have made the rotor into a squirrel cage by using three strips of No. 18 gage copper ½ in. wide by 2¾ in. long in each of the 41 slots, shortening them at the ends with an 11/16-in. ring of the same material. I shall appreciate it if someone will give me the winding data and other information I need to change this motor to a split-phase type.

North Bend, Oregon — E. M.

* * * *

Trouble With Heating Elements for Underground Tank

We are having trouble with the heating elements for a vertical tank that goes down about 40 ft. in the ground. We use Westinghouse space heaters, No. 299657, 220 volts, 1,250 watts, to maintain a temperature of about 400 deg. F. in the tank, which is insulated with firebrick and magnesite plaster containing some asbestos. Our trouble is that the elements either become grounded at short intervals, or the No. 10 solid copper wire used for connecting to the busbar burns off at the element. I should like to know (1) If this plaster has good insulating qualities at high temperatures? (2) Would it be objectionable to leave a round opening in the plaster around the element connections? (3) Would it be better to use steel instead of copper busbar connections?

Portland, Ore. — J. V.

* * * *

How Can These Bearings Be Made to Run Cool?

We have a motor-generator set that consists of a 25-kw. 125-volt, d.c. generator direct-connected to a 2,400-volt, three-phase, 1,800 r.p.m. induction motor. This set has three bearings of the ring-oiling type, the middle bearing being much larger than the end bearings. The latter bearings tend to run very hot, especially in hot weather, although the oil rings are functioning properly. The bearings never become so hot that the hand cannot be held on them for 20 to 25 seconds, but they are too hot for our peace of mind. The motor-generator set has been running almost continuously for four years, the oil being changed at intervals. The commutator and brushes are in good shape and the set is never fully loaded, running about three-quarter capacity. My opinion is that the proper oil is not being used in the bearings in hot weather, and I should like to know whether a mineral oil should be used exclusively. If so, what characteristics should it have. I shall also appreciate any other information regarding the best methods of making these bearings run cooler.

McGaheysville, Ga. — H. C. M.

ANSWERS *Received to Questions Asked*

Question

Effect of Reversing D.C. Leads on Alternator

Will some reader help us with the following problem? We have three three-phase, 2,300-volt, 60-cycle alternators that are operated in parallel. Once a year I want to reverse the direct-current leads at the collector rings of these alternators, in order to make the rings wear evenly. One machine would be changed at a time. After reversing the d.c. leads will the alternator be in phase with the other two machines so that I can operate it in parallel with them, or will I have to phase in each time I make this change?
Woodward, Okla. H. J. A.

ANSWERING H. J. A., changing the d.c. collector ring conductors will in no manner affect the synchronism of a machine unless we consider a hypothetical case of an instantaneous change during actual operation, in which event we could assume a theoretical reversal of the three-phase polarity.

In other words, H. J. A. can make the change he proposes and the alternator can be synchronized with the other machines afterward without any difficulty.

I am, however, somewhat skeptical about the necessity for this change. It is sometimes necessary, but that a yearly change should be necessary seems to be a little far-fetched. I had rather believe that the trouble from wearing of the rings is due to improper brush tension, a soft ring, or some other such cause as would be manifested by pitting, sparking, etc. On this basis it would be advisable to check the machine very carefully, to determine whether any such conditions exist, before adopting the above policy.

E. J. MORRISSEY.
Asst. Chief Engineer,
Western United Gas & Electric Company,
Aurora, Ill.

REPLYING to H. J. A., he need have no fear of any trouble if the d.c. ring-leads are reversed on one machine at a time. Once the machines are correctly connected the operating relations are definitely and permanently established. So long as the rotations or sequence of the phases is correct—that is, of course, established by the installation tests—the reversing of the d.c. leads will only reverse the polarity of each phase, but inasmuch as the machine can shift its phase position, the rotation being the same, the final result is the same when the units are operated in parallel.

The fundamental relation in paralleling machines is that the voltages in the different phases build up in the same order; if the relation is established the machines will automatically assume the correct relation through being speeded up or slowed down slightly. In the case of frequency changes, where a synchronous motor of one frequency drives a synchronous generator of another frequency, say a 25-cycle motor driving a 60-cycle generator, it is necessary, depending on the number of poles in each unit, to have the revolving members of the generators assume certain definite relations to each other when they are being paralleled. If the sets are being started from, say, the 25-cycle side, the synchronism indicator shows by the "fixed" position of the pointer whether the phase relation is correct. If it is not the field of one unit is reversed, a method known as "slipping a pole," until the correct position has been indicated; then the 60-cycle ends may be safely paralleled.

C. O. VON DANNENBERG.
Electrical Division,
General Engineering & Management Corporation,
New York, N. Y.

Question

Waterproofing Concrete Wall

During the past winter the paint peeled off the interior of one of the outside concrete walls of the building. Can any treatment be given to the exterior or interior surface which will prevent this? If any other reader has overcome a similar problem, I would appreciate his solution.
Chicago, Ill. E. D. F.

IN REPLY to E. D. F., the cause of the paint peeling off is probably due to cracking from expansion or vibration, or improper application in the first place. Expansion and contraction with temperature variations is a common cause of trouble. The paint used should have a coefficient of expansion similar to that of concrete so that both will expand and contract together. If they differ widely in this respect the paint will tend to crack and peel and be generally unsatisfactory.

Many paints do not work well on concrete, and it is always advisable to give the latter a priming coat of paint designed for this use, and then apply the finishing coat over it. I have found Smooth-On iron cement paint very effective for this purpose.

Painting in freezing weather or when the concrete surfaces are damp should be avoided, as peeling is very likely to follow. The concrete surfaces should also be well seasoned before the paint is applied. Some time is required to season concrete, and this may be the cause of the peeling in the present instance. W. E. WARNER.
Brentford, England.

Question

Location of Elevator Motors

Due to alterations in one of our four-story buildings, the location of the two present elevators is to be changed. But before the new electric elevators are installed, we wish to have readers advise us of the advantages of elevators equipped with overhead motors as compared with motors located at the foot of elevator shafts.
Portland, Ore. S. B. V.

IN ANSWER to S.B.V.'s question the advantages of the overhead machine as compared with the basement machine are: (1) Shorter cable and simplicity of roping. (2) Longer cable life. (3) Less number of idlers. (4) Does not require any floor space in the building. (5) In many cases decreases the load on the building.

The basement machine requires cables of considerably greater length—approximately three times the length of the cables required for the overhead machine—as the cable must be run from the car over the overhead idlers down to the basement and back up again over overhead idlers to the counterweights.

The overhead machine requires a cable run from the counterweight over the traction sheave down to the car and eliminates the two extra runs of cable to and from the basement, which are required for the basement machine, thus resulting in a less complicated arrangement of cable roping.

From the foregoing outline of the roping required, it will be seen that reverse bends in the cables are required for the basement machine, whereas the bends in the cable are in only one direction for the overhead machine. The reverse bends in the cable naturally result in a shorter life of the cables.

At least four idlers are required for the roping of the basement machine, whereas with the overhead machine no idlers are required. In some cases, however, one idler is required with the overhead machine. This arrangement is necessary when a large car must be used and it is impracticable to increase the diameter of the driving sheave to the extent of clearing the car and counterweight.

Basement machines use valuable floor space in the basement which in general could be used to good advantage for other purposes. Overhead machines are installed in penthouses at the top of the building and do not require floor space in the building.

Finally, the overhead machine is installed directly over the hoistway and imposes a load on the building equal to the weight of the hoisting machine plus the loads on the car and counterweight

ANSWERS *Received to Questions Asked*

cables, whereas placing the machine below imposes a load on the building equal to twice the load on the car and counterweight cables. Therefore, if the hoisting machine weighs less than the combined load on the car and counterweight cables the load on the building is reduced accordingly for the overhead machine. This relation of weights often occurs. W. J. NEUSTEDTER.

Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

Question

Size of Conductor in Three-Phase Circuit

Can someone tell me what size of copper conductors will be required in a three-phase circuit to transmit 400 amp. a distance of 600 ft. The voltage at the bus in the power-house is 2,300 volts, and 2,200 volts are required at the distribution center 600 ft. distant.

Louisville, Neb. D. F. Z.

ANSWERING D. F. Z.'s question, in an alternating-current circuit the impedance, rather than just the resistance, has to be taken into account when calculating sizes, and to do this it is necessary to know the spacing of the wires and the number of cycles at which the current is generated.

However, in the problem given the carrying capacity of the wire and not the voltage drop will be the limiting factor, as the distance is so short that the wires would get extremely hot if they were made small enough to lose 100 volts in only 600 ft.

In the writer's opinion, the wires should be at least No. 0000 size, and perhaps as large as 500,000 circ.mil, depending on the insulation, if any, the cost of power, the load factor, cost of building the line, and other factors entering into the decision as to how much money could be invested in the line and yet show a saving because of reducing loss of power.

Westfield, N. J. G. H. MCKELWAY.

THE question of D. F. Z. does not state whether the conductors are to be carried overhead on poles, exposed inside on cleats, or run in conduit. Under any condition, however, the size of the conductor is limited by the heating rather than by the voltage drop, as an approximate calculation shows that a No. 2 A.W.G. conductor would be sufficient, theoretically. Actually, however, this size would be very much too small and the following sizes are, therefore recommended:

For open construction, outside ..... 350,000 circ. mil
For single-conductor cable in conduit ... 400,000 circ. mil
For a three-conductor cable in conduit ... 650,000 circ. mil

In the case of the open construction it would be best, if the conductors are not spaced in a triangle, to transpose them to avoid any unbalancing of the voltages between conductors. It would probably be sufficient in this case to make three transpositions, locating the first, say 200 ft. from the starting point, the second 400 ft., and the third at the terminating point. This method would allow each conductor to occupy the same relative position in the run for the same distance and the relation would be the same for all three at the end as it was at the beginning.

C. O. VON DANNENBERG.

Electrical Division,
General Engineering &
Management Corporation,
New York, N. Y.

Question

Rewinding a Portable Drill Armature

We have a small electric drill, of which the armature winding has been stripped, and I am anxious to secure information which will enable me to carry out the job of winding this armature. I believe this drill is a Thor, but the name plate, identification marks and serial number are gone. The motor is a universal type for operation on either direct current or 60-cycle alternating current. Armature is 1½ in. diameter, and contains 14 slots; commutator is 1⅛ in. diameter and has 42 bars. I would like to know the size wire to use, and any other information that would help in the correct winding of this armature.

York, Pa. M. S.

THE SMALL ARMATURE described by M. S. undoubtedly belongs to a Thor drill. The winding data are as follows: There are 14 slots and 42 commutator bars. The coils should be wound with 10 turns of No. 28 wire. The coil span is 1 and 6. The commutator leads should be brought out straight from the top coil end. The coils extend ⅝ in. from the core on the fan end.

Good results may be obtained by winding this little armature by hand.

Before starting to wind the coils, care must be taken to slip a fiber tube of the proper thickness over the shaft on the fan end to allow space for the sleeve on the fan when the winding is completed.

Detroit, Mich. CHARLES GUILBAULT.

ANSWERING the questions by M. S., the armature coils for his drill motor should consist of 11 turns of No. 28 single-cotton-covered wire wound three in hand, with a coil pitch of 1 and 6. There are 42 commutator bars and the commutator leads should be brought straight out.

Buffalo, N. Y. VINCENT HURST.

Question

How Does Increase in Frequency Affect Core Iron?

I shall appreciate it if readers will give me the answers to the following questions: (1) What is the highest frequency in cycles per second at which commercial core iron can be worked? I am referring to the iron used in transformers and induction motor will operate on highest practical frequency that an iinduction motor will operate on with reasonable losses? (3) Which loss increases the most rapidly as the frequency is increased?

Detroit, Mich. H. F. W.

REPLYING to H. F. W., core losses consist of hysteresis and eddy current losses. Hysteresis losses vary directly with the frequency. Eddy current losses vary with the square of the frequency. Therefore, the latter losses increase more rapidly with increasing frequency, but with commercial frequencies the hysteresis losses are so many times greater than the eddy current losses, that the total core losses may be considered as varying directly with the frequency. In fact, the two losses do not become equal before a frequency of several thousand cycles is reached, depending on the thickness of the laminations and the resistance of the iron.

In the case of an induction motor of standard frequency, a current of higher frequency but normal rated voltage could be applied with safety, without making any changes in the motor, were it not for the fact that the speed would be increased in direct proportion to the frequency, and might be too high for the rotor to withstand the centrifugal force.

Disregarding the effects of high speed, the result of increasing the frequency will in general be as follows: The impedance of the motor will be increased in proportion to the frequency; therefore, the magnetic flux density of the core and the magnetizing current will be inversely proportional to the frequency.

However, as the increase in frequency tends to increase the losses, the simultaneous reduction in flux density will tend to reduce these losses, and even overbalance the effect of the higher frequency, so that the net result is a reduction in core loss, providing the frequency only is raised, that the voltage remains as before, and that no changes are made in the winding. The above reasoning holds true for transformers as well

It stands to reason, however, that whenever it is desired to operate a motor or transformer on a higher frequency, the windings should be changed in order to work the material in the machine to capacity and get the maximum efficiency.

Evanston, Ill W. E. PAULSEN.

AROUND THE WORKS

THIS SECTION *is especially devoted to short articles describing ideas and practical methods devised to meet particular operating conditions. The items may refer to mechanical details of installation, inspection, testing, wiring, repair, maintenance, replacement, and emergency or unusual installations of equipment tributary to production. Special attention is given to shop or bench tools and short cuts or improved methods of handling work brought into the repair shop. Contributions from our readers are always welcome.*

* * * *

Suggestions on the Application of Fasteners to Fabric Base Belts

THE kind of fastener to be used on fabric base belts will vary as to type with different drives and the preference of operators; any of the better known fasteners or lacings will give good results if of correct size as specified for the work by their manufacturer. From an operating standpoint, it is essential that the ends of the belt be cut squarely and that the fastener or lacing holes do not cut the lengthwise threads of the fabric.

If a belt is not cut squarely it will have more load on one side than the other and will stretch or tear at the fasteners on the overloaded side, and being out of alignment, will not run true. If a belt which runs off to one side of the pulleys is taken off and stretched out on the floor, it looks like the arc of a great circle and is condemned as not having been made straight. This may be caused by not cutting the ends square, however. After a belt is curved it is almost impossible to straighten it.

Frequently a belt which is improperly installed runs so far off to one side of the pulley that a board is placed against the edge of the belt to keep it on the pulleys. Although belts are never intended for use as band saws, they are condemned if the edge frays after cutting through an inch or so of wood. Incidentally, the belt is torn on the short side by the fasteners and plies opened up; sometimes the plies break just behind the fasteners. When the plies are opened dirt and air will work in between them and be driven lengthwise through the belt by the pulleys. This causes "bootlegging" (opening up of the plies) and may result in a break anywhere throughout the belt.

Punching holes that cut the warp threads will, of course, weaken the belt by decreasing the serviceable width by the total width of the holes. Sometimes belts have a fifth of the entire width cut out in this way and whether they fail or not, the punching is costing 20 per cent extra.

It is taken for granted that in aligning the pulleys that the crown or exact center of face have been carefully placed in line. Where the pulleys are not aligned the belt will "climb" to one side or run off the pulley face and make about half of the belt do the work. This throws an extra strain on the fasteners.

Chicago Ill. E.D.F.

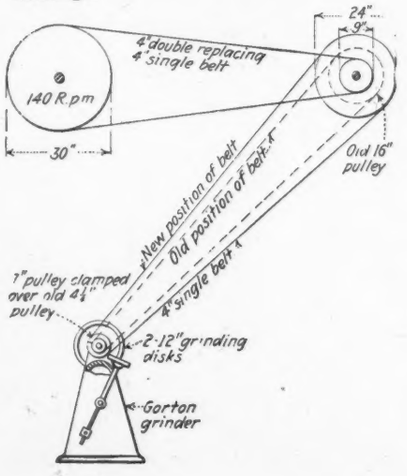
Increasing Pulley Diameters Made Drive Pull Load

IN ORDINARY belt drives, when improperly designed, an almost unbelievable amount of power is lost needlessly. The following example covers an unsatisfactory belt drive on a Gorton grinder and shows how it was corrected by simple changes.

This type of grinder has a chuck at each end of the spindle with abrasive rings clamped in them and a swinging table on which the work is blocked while passing across the face of the grinding rings. Both thrust and radial loads on the bearings are heavy at times. However, the grinder had babbitt bearings of ample size which were in excellent physical condition. The report on the drive was that "it never seemed to have power enough, although it did when first put in."

* * * *

OVERCOMING THE FAULTS in a belt drive. The old drive would not pull the load but when the pulley diameters were increased the drive delivered all the power necessary without slippage. Increasing pulley diameters, which increases the belt speed, is a simple method of improving a belt drive and also relieves the tension of the belt and the pressure on the bearings.



The layout of the drive is shown in the drawing. Good, 4-in. single belts were in use, applied very tight. A 30-in. pulley was used on the lineshaft; this was the maximum with the hangers. From there, the belt drove to a 9-in. pulley on the countershaft, which carried a 16-in. driving pulley leading the second 4-in. belt to the 4½-in. cast-iron pulley on the spindle of the machine. This last driven pulley was considerably worn from the belt slippage. The theoretical speed of the grinding wheels was 1,784 r.p.m. but this was not being realized by several hundred revolutions when the load was on.

An investigation showed that the belt in the first reduction should have been of greater capacity than that in the second reduction but, instead, they were of the same size, with the added inconsistency of the first belt's slower speed, which reduced its transmitting power over 40 per cent. To remedy this, a 4-in. double belt was installed in place of the first single belt.

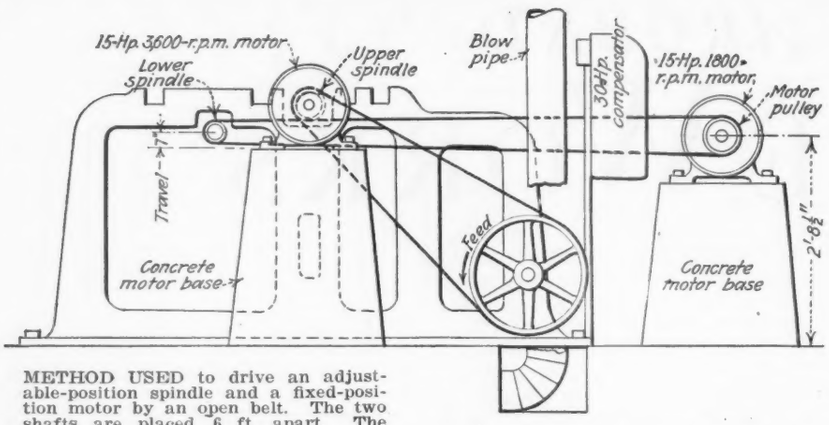
Obviously, the fault with the second drive was that the pulleys were of too small diameter. This was corrected by putting a 24-in. pulley on the countershaft and a 7-in. one on the machine spindle; this was the maximum clearance at those respective locations. Because of the shrunk-on members at each end of the grinder spindle, the new pulley was made in halves and bolted over the old one. This new cast-iron pulley was given a $\frac{1}{8}$-in. crown or taper for 1 in. at each edge, leaving 3 in. of straight surface in the center.

These changes were so successful in transmitting full power to the machine that both grinding wheels may now be loaded to capacity at the same time without any slippage.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Manufacturing Company,
Middletown, N. Y.

Driving Adjustable Spindle from Fixed-Position Motor

ABOUT two years ago it was decided to adopt motor drive for all the machinery in our main plant, which at that time was belted to lineshafting and driven by two Corliss engines. In looking over some of the various jobs tackled during the change-over period, one in particular stands out as very in-



METHOD USED to drive an adjustable-position spindle and a fixed-position motor by an open belt. The two shafts are placed 6 ft. apart. The adjustable spindle at the left moves 7 in. on a vertical plane and so changes slightly this center distance, but not enough to seriously affect the drive.

* * * *

teresting—not so much from an engineering standpoint, perhaps, as from the ingenuity required.

Among the woodworking machines to change over was a Whitney, 30-in. double surfacer, or planer, which had previously been driven from a countershaft with a double-belt drive to each spindle. The position of the upper spindle was fixed, but the lower one could be raised and lowered about 7 in. to take care of different thicknesses of stock. The connection of the drive to the upper spindle was simple, as shown in the sketch. This spindle was direct-connected through a flexible coupling to a 15-hp., 3,600-r.p.m motor, which was mounted on a concrete pedestal. It was not so simple to devise a method of connecting a motor directly to the lower spindle due to the construction of the machine, and also on account of the necessity of raising and lowering the spindle.

We finally decided to place the motor on the floor at the out-feed end of the machine and drive the spindle by means of a belt, using an idler to take up the slack necessary to compensate for raising and lowering the spindle head. While waiting for the arrival of the idler attachment, we got along by moving the motor on its slide rail to compensate for the changes in center distance. This was too much of a makeshift, so even before receiving the idler pulley we thought of the method which is illustrated by the horizontal belt drive in the accompanying sketch.

It will be noted that the upper spindle is direct connected, as previously explained. The motor for the lower head is mounted on a concrete pedestal at the in-feed end of the machine, at the right in the accompanying illustration. The only precaution necessary was to have the center line of the motor shaft at a distance from the floor equal to that of the center line of the lower spindle when it was halfway between its extremes of travel. The motor was mounted to give a center distance of 6 ft. between the pulleys on the motor and the movable head and the belt cut accordingly. This center distance varied slightly as the spindle was moved up and down. This was taken care of by the elasticity of the belt.

Since this open belt transmission was installed we have experienced no trouble due to slippage. Another advantage is that heretofore wasted space is used. The machine is accessible from all sides. Because of the position of the compensator and the shaving pipe, it has not been necessary to use a belt guard.

Incidentally both motors are controlled by one compensator by using a relay for each motor. It has not been necessary to renew the line fuses since installing the motor as described.

Plant Engineer, J. F. WINN.
The J. G. Wilson Corp.,
Norfolk, Va.

Overcoming Shock and Moisture on Board Mill Drive

MOST paper mills have several machines that operate under conditions which may be termed "hard drives." Moisture, continuous operation under heavy loads, and starting under full load give a type of service which is very trying on the driving elements.

One of the drives which gave considerable trouble at the plant of the Chicago Coated Board & Paper Co. was on the first-press drive of a board mill. One of the helper-drive belts, the two wide belts at the right in the accompanying illustration, slips more or less according to the thickness of the board. This results in severe shocks and vibration being transmitted back into the speed reducer which has its slow-speed shaft direct connected through a flexible coupling to the main shaft of the helper drive.

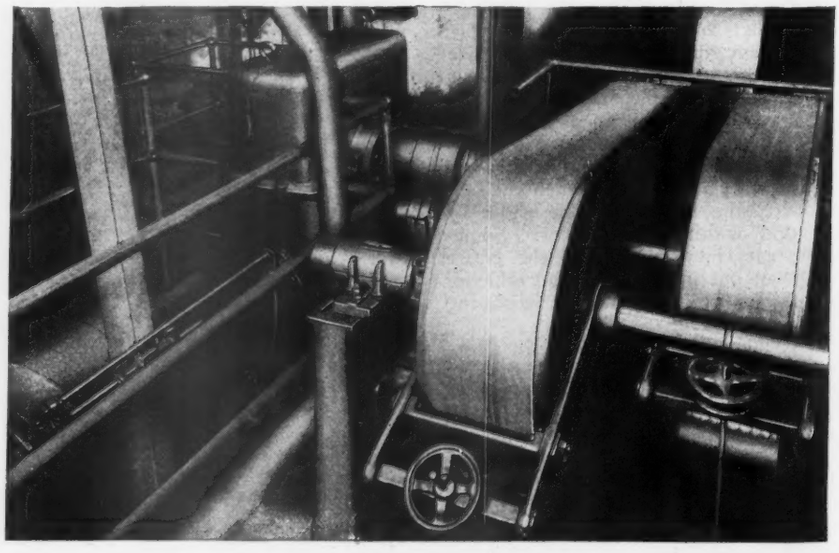
The speed reducer is belt driven from an engine-driven lineshaft. This drive had always given trouble because the speed reducer was too closely rated for the work it had to do and would overheat during the five days of continuous operation from Monday morning until Saturday morning.

To overcome the difficulties in connection with this drive a new Cleveland Worm & Gear Co., 100-hp., 8-to-1 reduction ratio, worm speed reducer was installed by the Beloit Iron Works. Dodge-Timken tapered roller bearing pillow blocks were used on the short shaft at the left which carries the main driving pulley. This shaft is direct-connected to the worm shaft through a Bartlett-Hayward flexible coupling. A Moore & White variable-speed drive on the engine governor permits a variation of speed from 80 to 450 r.p.m. on the worm shaft. Because of the moisture, Test-special rubber belting, manufactured by New York Belting & Packing Co., is used for all belts.

The old worm reducer had been in use about five years. This reducer had a rating of 75 hp. which was not sufficient for the continuous operation. It was not discarded when removed but was placed on the first-press drive of a smaller board machine, where it operates very satisfactorily. A companion mill was changed over to be driven by similar equipment. During

* * * *

FIRST-PRESS DRIVE on a board mill. On the former drive the worm speed reducer had been too closely rated for the severe service to which it was subjected and so overheated. The reducer was replaced with this larger unit. Continuous service requires an ample oil supply and radiating surface on the reducer to prevent overheating.



the nine months that these two new drives have been in operation they have given no trouble. This is largely due to the ample rating of the unit, the much larger radiating surface of the gear case, and the ample oil supply which does not heat so quickly.

Another source of considerable trouble was in the cylinder bearings. Because of the moisture these bearings were difficult to lubricate and keep lubricated.

Beginning in 1918, SKF ball-bearing pillow blocks were installed on these cylinder shafts whenever old bearings had to be replaced. Some of these original ball bearings are still in use. However, whenever water gets past the seal the bearing rusts and must soon be replaced. The infrequent replacement of a ball bearing is the matter of only a few minutes, whereas it requires several times as long to replace an old plain bearing.

Varying the Speed to Suit the Product Handled

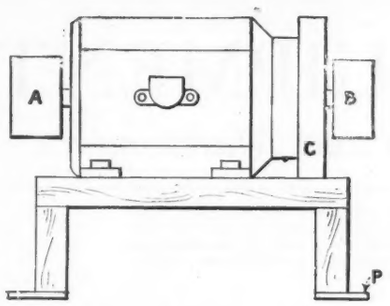
ONE of the important advantages of variable-speed drives is the ability to operate at a selected speed that will give the highest production under varying circumstances. How this is used to advantage in one instance is shown in the accompanying illustration. Here a No. 13 Lewellen complete ball-bearing, variable-speed transmission unit is connected to a fan that is used to force air through a drier.

Previous to the installation of this transmission the operation of the fan caused some serious difficulties. The drier is used in manufacturing road-building material, consisting of crushed stone coated with a bituminous solution treated to prevent the coating from crystallizing. When the fan was operated at a constant speed it was found that if the speed of operation was most suitable to dry coarse stone after treatment, the same speed gave an air velocity too high for the finer grades of crushed stone and would blow them out through the end of the drier. Likewise, a speed suitable for fine crushed stone was not satisfactory for the heavier stone.

When the variable-speed transmission was placed in the drive the manufacturer was able to get the correct air speed for drying each size of stone most rapidly and without the waste or loss that had been occasioned previously.

* * * *

VARIABLE-SPEED TRANSMISSION UNIT on fan drive. This drier is used in manufacturing road-building material consisting of crushed stone coated with a bituminous solution. The variable-speed transmission enables the manufacturer to use the most economical air speed for the various sizes of stone.

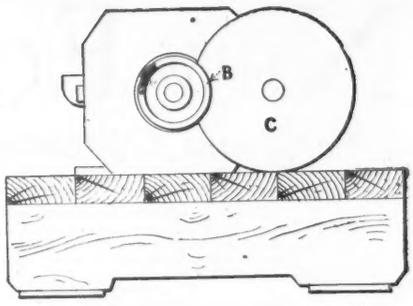


Portable Motor Unit for Emergency Service

IN A very large plant where each machine is driven by an individual motor, the old method of "hustle and excitement" whenever a motor gave trouble has been eliminated by employing a portable motor unit, which can be hooked up in an hour's time. Under the present arrangement, the portable unit is always ready to move the instant a call comes into the repair shop.

It consists primarily of a 15-hp. motor mounted on a skid of heavy construction, which can be moved by the ordinary lifting trucks employed for process work. Thus the motor can be shifted to the point of trouble in a very short time by any of the trucks that happen to be near by.

The unit, is constructed to provide a wide variety of belt speeds. A pulley, *A*, is attached to one end of a special back gear shaft, *C*, and another pulley, *B*, is mounted on the rotor shaft. With this arrangement, and by changing the size of pulleys used at *A* or *B*, a wide range of speeds is available for driving any machine in the factory at its normal capacity.



THE MOTOR IS MOUNTED on skids and provision made as shown for obtaining any desired speed.

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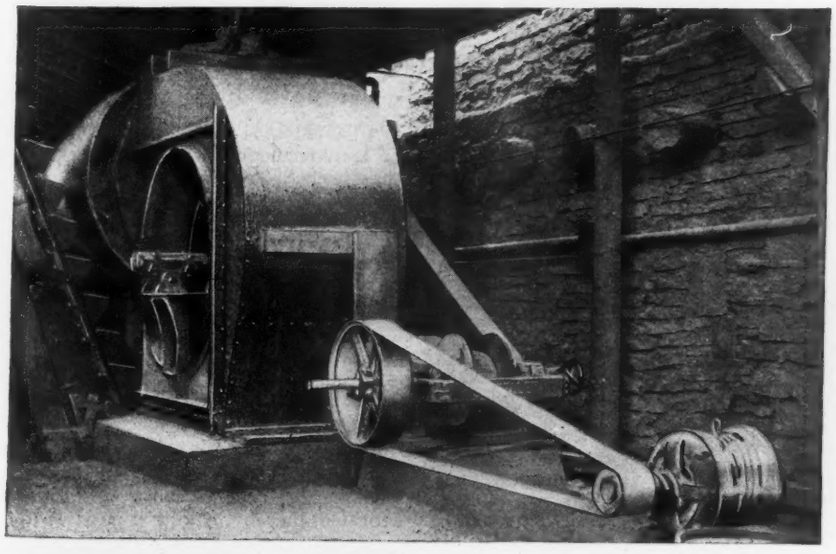


Easily Constructed Truck for Acetylene Outfit

A LARGE sawmilling organization operating several logging locomotives and two large mills, maintains a repair shop for the upkeep of the engines and the sawmill and planer mill machinery. One of the most valuable tools in such a shop is the acetylene welding torch. To overcome any inconvenience when transferring the outfit about the shop or the yard, as is frequently necessary, the welding engineer has made a very handy truck from an old floor lumber truck.

The wheels and axle were first removed from the lumber truck or "dollie." The axle was bent at four places to right angles in order that the central portion of the axle would be dropped about 6 in. A rectangular frame was then made of $\frac{1}{4}$x1$\frac{1}{2}$-in. flat iron by bending two pieces 6$\frac{1}{2}$ ft. long to a U shape, allowing 1$\frac{1}{2}$ ft. across the bottom of the U. Two other pieces were formed into a 1$\frac{1}{2}$-ft. square and their ends welded together. These two squares were riveted to the upright sides of the U-shaped pieces, one at their top ends and the other 7 or 8 in. above the bottom. A piece of sheet metal 1$\frac{1}{2}$ ft. square was cut to form a bottom to the frame, and placed on the bends or horizontal portions of the U pieces. This formed a basket or framework 2$\frac{1}{2}$ ft. high by 1$\frac{1}{2}$ ft. square. Two $\frac{1}{2}$-in. holes were then drilled through opposite edges of this metal bottom, so that it could be clamped by two U-bolts to the dropped portion of the axle.

Before setting the frame on the axle, one end of a piece of 1-in. rod, 4 ft. long was welded to the center of the axle. A 10-in. T was welded on the other end to form a handle or tongue for the truck. The wheels were then remounted and the oxygen and gas cylinders set upright in the rectangular frame.

Cairo, Ga. L. M. JORDAN.

NEW EQUIPMENT

For Plant Operation and Maintenance

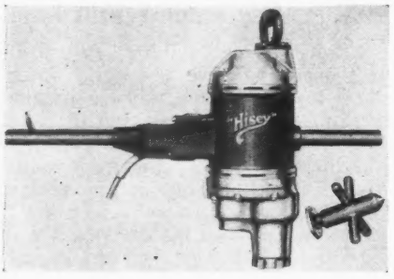
Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Electric Drill

MARKETING of a 1¼-in. capacity drill has been announced by The Hisey-Wolf Machine Company, Cincinnati, Ohio.

The motor is provided with ball bearings which, it is claimed, are mounted so as to eliminate all slip and creeping action. Brush-holders with adjustable spring tension are mounted as a separate unit on a Bakelite yoke, permitting brush adjustment when necessary. The gear on the armature shaft is removable and the compound gear shaft is supported in a bearing at each end.

A No. 3 Morse taper socket is fitted to the drill spindle, which is automatically lubricated through the gear case.



Hisey 1¼-in. Capacity Drill

All pressure applied while drilling is carried by the end handle cover, which is independent of the motor and motor bearings, thus relieving them of all strain.

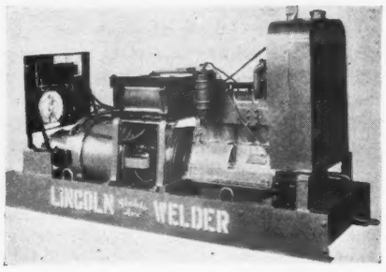
Gas-Engine-Driven Welder

GROWING demand for a self-contained, light and portable arc welder has led The Lincoln Electric Company, Coit Rd. and Kirby Ave., Cleveland, Ohio, to announce a new unit, known as Model S-1960.

The new unit has a rating of 200 amp., according to N.E.M.A. standards, with a current range for welding duty of 50 to 300 amp., and operates at a speed of 1,500 r.p.m. Motive power is provided by a four-cylinder Type H-9 Continental Red Seal engine.

The welding generator and engine are mounted on a structural base welded into a solid piece of steel. This welded steel base, it is claimed, provides maximum stiffness and rigidity with minimum weight. The whole unit weighs only 1,580 lb. and is 76 in. long by 25 in. wide.

The generator is also constructed of steel instead of cast iron, usually used.



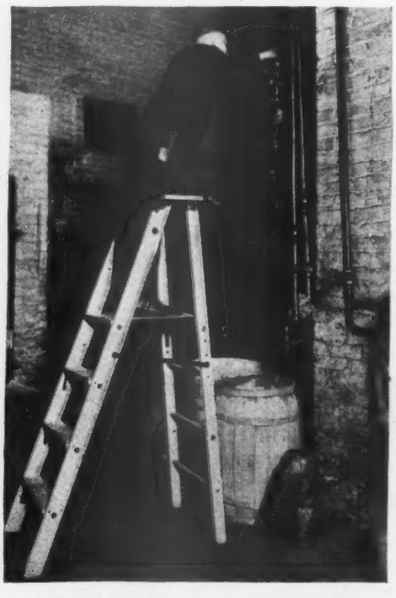
Lincoln Model S-1960 Welder

A steel switchboard is provided in place of the usual slate or composition board, thereby reducing the possibility of damage in the field.

It is stated by the company that this unit is not designed to replace its present heavy-duty, engine-driven equipment, but to meet the need for a light, sturdy unit.

Platform Step Ladder

SEVERAL new features distinguish the Gold Medal Platform Step Ladder which has been placed on the market by The Patent Scaffolding Company, 1550 Dayton St., Chicago, Ill. One of the chief features is an automatically-folding platform that provides ample room for the feet, and increases freedom of action.



Gold Medal Platform Step Ladder

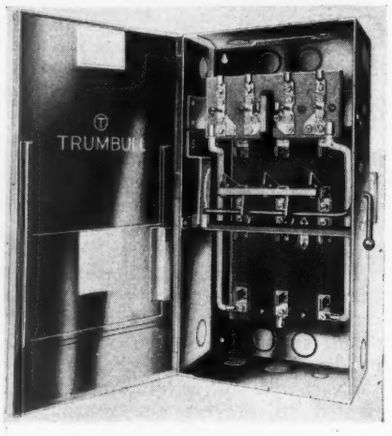
With the addition of a plank or light platform two ladders can be used to advantage for the construction of a temporary scaffold, as the back rungs coincide in elevation with the steps.

These ladders are constructed of straight-grained Canadian spruce, and selected hardwood. They are available in sizes ranging from 3 to 18 ft. in length.

Enclosed Switch

A NEW line of polyphase switches known as Type C has been announced by The Trumbull Electric Manufacturing Company, Plainville, Conn. They are available in sizes from 60 to 400 amp. with test connections, and from 60 to 600 amp. without test connections.

These switches are of slate-base construction and, as will be noted from the illustration, the contacts are mounted on the top, where they can be inspected when the switch is in the "on" position. The test connections are mounted in an accessible position above the jaw posts.



Trumbull Type C Switch

This construction also prevents the tester from coming in contact with the live side of the line while making connections.

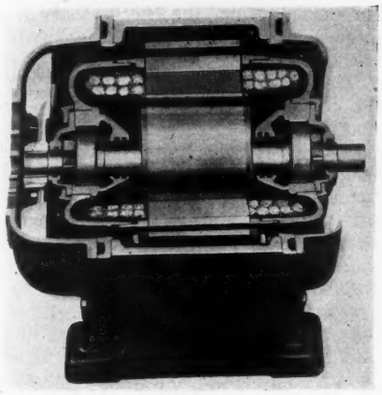
As desired, these switches can be furnished with the fuses sealable or accessible.

Totally-Enclosed Motor

A COMPLETELY-ENCLOSED, ventilated motor with a 40-deg. rating, has been brought out by the American Electric Motor Company of Cedarburg, Wis., a subsidiary of the Splitdorf-Bethlehem Electrical Company.

The construction is shown by the illustration, from which it will be seen that the enclosed hoods seal the winding hermetically, it is claimed. The hoods are telescoped into a ring fastened to the stator laminations, the surfaces of which are machined.

Cooling of this Type P-K motor is unusual in that air is said to be driven *through* as well as over the stator laminations. The stator core is perforated, thereby making it possible to re-



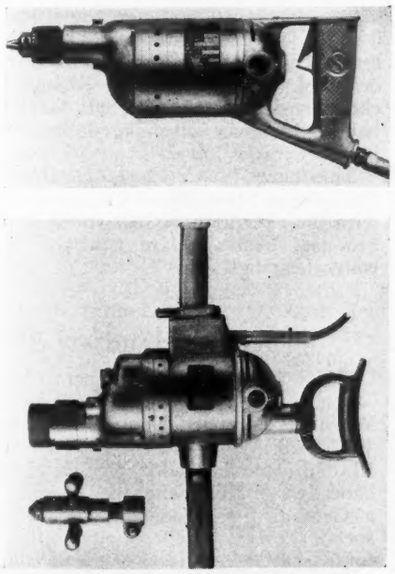
American Electric Fully-Enclosed Motor

move the heat where it originates. Air in the enclosed portion is agitated by malleable-iron fans shrunk on the motor shaft. Ball bearings of the cage type are used and the enclosing hood of the motor can be removed without disturbing them. Entrance of dirt into the bearings and leakage of grease from them are prevented by felt washers imbedded in the cap.

The rotor is of the usual construction, with the end rings electrically welded to the bars forming, it is claimed, an indestructible one-piece squirrel cage of uniform material.

Portable Electric Drills

A NEW line of heavy-duty portable electric drills has been placed on the market by The Standard Electric Tool Company, 1938 West Eighth Street, Cincinnati, Ohio. This line is made in two styles and in five sizes rated at $\frac{5}{16}$ and $\frac{1}{4}$ in. with a grip handle, and at $\frac{3}{4}$, $\frac{7}{8}$, and 1 in. equipped with a Morse taper socket, spade handle and a feed screw.



Standard $\frac{5}{16}$-in. (above) and $\frac{3}{4}$-in. Models Electric Drills

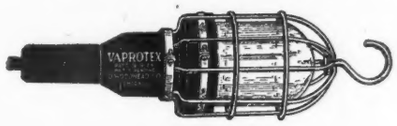
Universal-type General Electric motors are used. The chrome nickel steel gears run in grease and the shafts are mounted on SKF ball bearings. The motor housings are made entirely of aluminum.

Vaporproof Lamp

KNOWN as the Vaprotex unit, a new vaporproof extension lamp as been put on the market by Daniel Woodhead Company, 15 North Jefferson St., Chicago, Ill.

The handle and socket holder are one unit, molded of a rubber compound and threaded to hold the globe. Added strength is given and danger of breakage further minimized by the use of a heavy wire guard that clamps both the glass globe and the socket covering.

The dust and vaporproof globe is made of heat-resistant glass and the



Vaprotex Extension Lamp

one-piece socket is of molded Bakelite. It is claimed that no cement or sealing compound is used, all lead wires and contacts being molded into the socket. A special taped joint completes the sealing so that it is said this extension lamp can be used under water without danger of a short circuit.

The guard is made of heavy wire which is cadmium-plated to prevent rust. All of the joints are electrically welded.

Fixture Aligner

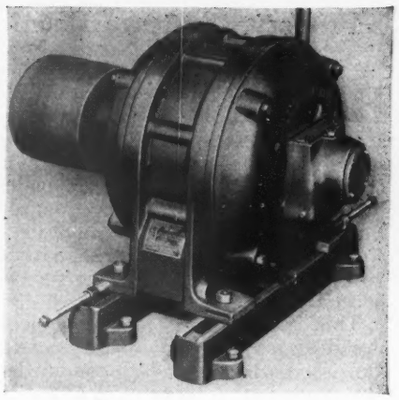
A NEW ball fixture aligner has been brought out by the Benjamin Electric Manufacturing Company, 120-128 South Sangamon St., Chicago, Ill.

This new device is said to be easily and quickly installed and is suitable for all industrial locations where the lighting fixtures are suspended directly from the outlet box.

It is claimed that even on an installation where the slope is as great as 45 deg. this aligner will permit the fixture to hang plumb and, in addition, the ball-and-socket design protects the fixture against jars and shocks.

Full-Voltage-Starting Motor

A LINE of squirrel-cage induction motors adapted for starting on full line voltage is being placed on the market by Allis-Chalmers Manufacturing Company, Milwaukee, Wis. These motors are normal-torque, high-reactance machines and, it is claimed, will not draw starting current in excess of the limits recommended by the Electrical Apparatus Committee of the



Allis-Chalmers Line Start Motor

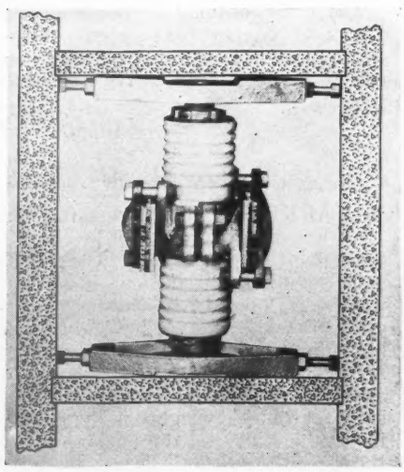
National Electric Light Association.

They are built in ratings of $7\frac{1}{2}$ to 30 hp., 600 to 3,600 r.p.m., low voltage, and are available with either sleeve or roller bearings. A magnetic switch with push button control is the only starting equipment required.

Bus Support

A NEW, double, bus or connection support developed by the General Electric Company, Schenectady, N. Y., requires no setting of bolts in concrete or drilling for expansion bolts, but is mechanically expanded against the sides, top and bottom of the compartment or enclosure in which it is installed. It consists of a cylindrical bushing with expansion elements at either end and a connection clamp over the middle.

The expansion element is a pipe nipple with a stationary flange and a movable locknut. Vertical expansion is accomplished by unscrewing the locknut against the bushing until the assembled unit bears rigidly against the top and bottom shelves. The stationary flange is provided with a screw and locknut at either end by means of which it is expanded horizontally and firmly held against the sides of the concrete inclosure.

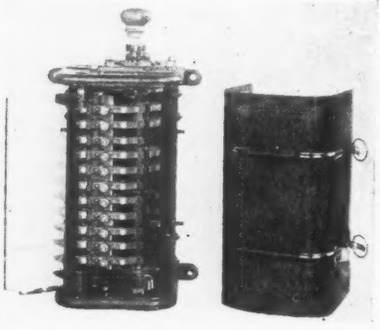


General Electric Bus Support

Primary-Resistance Drum Switches

BEARING the designation CR-3200-1250 a new line of primary-resistance drum switches for use with squirrel-cage induction motors on small cranes, hoists, etc., has been announced by the General Electric Company, Schenectady, N. Y. They are designed for a maximum primary voltage of 550 volts, and the maximum rating for two- or three-phase service is 15 hp.

This is a primary reversing switch designed for wall mounting; it can be furnished with a standard conduit box. It is made in two forms; CR-3200-1250-B for hoists where the motor is overhauled in the lowering direction, and CR-3200-1250-A for hoists where the motor is not overhauled in the lowering direction. The former provides four points hoisting and one point lowering: the latter provides four points forward



General Electric Primary-Resistance Drum Switch

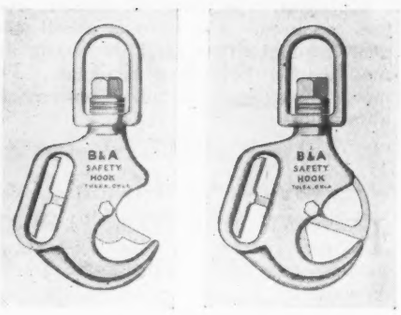
and four points reversing. It is designed for use with machine tools or general-purpose applications.

These switches are built without operating mechanism so that the user may select the type of operating equipment desired. The dial plate for the horizontal handle is assembled with the drum switch and is removed when the vertical handle or rope wheel attachment is to be used.

The switches may be obtained with dust-tight covers for cement mill or similar service where the equipment will be subject to excessive non-explosive dust.

Safety Hook

MARKETING of a new safety hook has been announced by B & A Specialty Company, Tulsa, Okla. This hook is made in but one size, which weighs 27 lb. and has a tested capacity of 20,000 lb. load. The body of the hook is a steel casting, and the bails are drop forgings. It is said to be balanced in such a way that it is not necessary to lift the weight of the hook to insert the load, and the load itself locks the hook shut, until it is opened by hand pressure on the handle. Pressure must be applied at right angles, making



B & A Safety Hook in Open (Left) and Closed Positions

it practically impossible, it is claimed, to open it accidentally.

The hook is 16 in. long, 9 in. wide and 2 in. thick, and has general lines that will not permit it to foul or catch in riggings. It is fitted with ball bearings of the Aetna inclosed-race type.

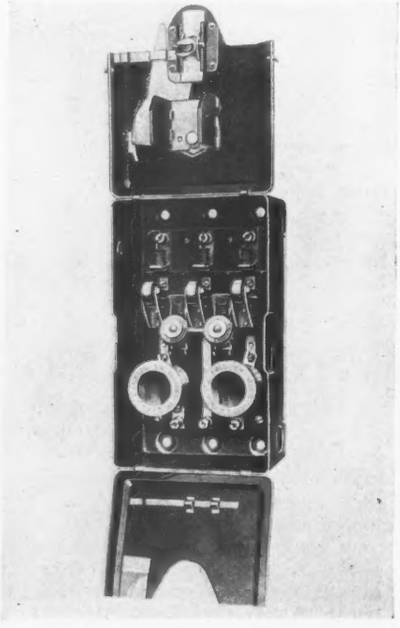
Manual A.C. Starter

MARKETING of a new, manual across-the-line a.c. motor starter, Bulletin 9115, is announced by The Cutler-Hammer Manufacturing Company, Milwaukee, Wis. Designed to meet the need for an inexpensive manual starter, it includes such advantages as overload cutouts, cadmium-plated, double-break, roller-type contacts, and small size.

The roller-type contacts break the arc in two places, giving several times the life of ordinary contacts, it is claimed. In addition, the contact rollers turn after each operation to present a new contact surface.

Complete motor protection is obtained during both the starting and running periods. The thermal overload

Cutler-Hammer Bulletin 9115 Across-the-Line Starter

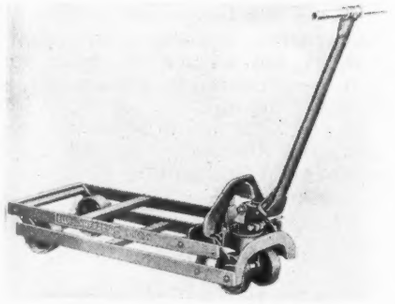


cutouts provide the necessary time interval to take care of starting inrushes without shutting down the motor.

The enclosing case is dustproof and the cover is in two parts. This permits opening the lower section only, for replacing fusible links in the thermal overload cutouts. The cover can be opened only when the starter is in the off position and all current-carrying parts are dead. Installation can be made without removing the panel from the case.

Lift Truck

DEVELOPMENT of a new, single-stroke lift truck for which a number of advantages are claimed has been announced by Lewis-Shepard Company, Watertown, Mass. The principal features claimed for this truck are that it lifts the load with a single stroke of the handle and that it can be operated with



Lewis-Shepard Type R Single-Stroke Lift Truck

the handle in any position within a radius of 180 deg.

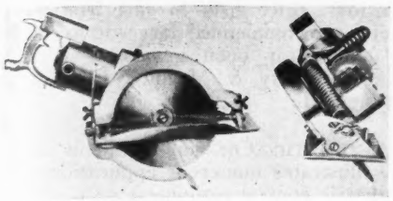
It is said that two new principles of lift truck construction are embodied in this new model in that the lift is accomplished both by rolling movement and by direct vertical thrust movement. According to the manufacturer, when lifting with the handle at the side the lifting force has no tendency to tip the load because the pulling force is always centered. In addition, the lifting mechanism is so constructed that the handle is never disengaged from the load when it is lowered.

This new lift truck is constructed throughout of malleable iron and steel with the exception of the wheels which are cast iron and are equipped with roller bearings.

Electric Handsaw

THE Type B portable electric handsaw has been announced by the Wodack Electric Tool Corporation, 4627-4629 West Huron St., Chicago, Ill. In common with the other electric handsaws of this make, the Type B has a General Electric universal motor of special design, which can be furnished for operation at 110, 220 or 250 volts. Anti-friction bearings are used throughout.

One of the features of this saw is that



Wodack Type B Electric Handsaw

it can be used for bevel sawing at any angle up to 60 deg. This is accomplished by a tilting saw base that can be set and locked at any angle within the above range by means of a slide and locknut.

An innovation has been made in the flexible mounting of the saw blade on its arbor, which reduces vibration so much that the life of the saw as a whole is said to be greatly prolonged.

One other feature which adds to its value is the coupling that connects the motor with the worm drive. In case the saw blade should get caught and hold in the lumber, the safety coupling will release the motor, thus insuring it against damage.

Motor Starter

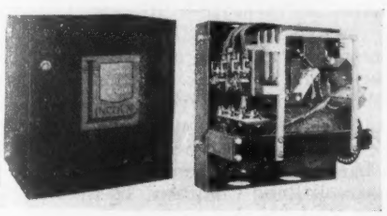
A NEW automatic induction starter with two adjustable features has just been announced by the Lincoln Electric Company of Cleveland, Ohio. One of the adjustments is in the starting current and torque, and is made by changing the position of the rotor in the regulator, which is index-mounted for ease in setting.

The other adjustment is in the current at which the throw-over takes place. The throw-over is controlled by a retarding solenoid which is operated by the motor current. The pull of this solenoid can be adjusted by a simple lock rod arrangement on its plunger.

The motor is controlled by the conventional start and stop buttons. When starting, the correct voltage is applied to the motor, and the starting current is held within the desired limits. After the motor comes to speed and the current has dropped to the desired value, the switch automatically assumes the running position without interrupting the torque of the motor.

The contacts in this switch are designed to give that wiping action which is a feature of the modern switch. Overload protection is afforded by thermo-relays and the no-voltage protection by no-voltage release control.

Lincoln Automatic Induction Starter



Reflectors

ONE OF THE new developments on industrial equipment recently announced by the Ivanhoe Division of The Miller Company, Cleveland, Ohio, is a complete line of heavy-duty reflectors and holders.

This is a new line of porcelain-enameled steel reflectors in the R.L.M. dome, shallow dome, standard bowl, standard angle and glassteel diffuser types with a rolled threaded neck of heavy gage copper. These collars are securely locked into the form and it is claimed will not become loosened or turn in service.

Holders are available for these reflectors in cast aluminum and stamped enameled steel for attachment direct to the outlet box. Also, suspension types of stamped enameled steel or cast iron, tapped for ½-in. pipe can be furnished. These holders are supplied with either medium or mogul porcelain sockets.

Paint-Spraying Outfit

THERE has recently been placed on the market a small spraying outfit known as The Atomister, manufactured by The Atomister Corporation, Rahway, N. J. It weighs only 5 lb. complete and consists of a universal-type motor, which will operate on either alternating or direct current, driving a small compressing unit that delivers air at 17 to 20 lb. pressure for producing the spray. The paint or other material is held in a container attached to the lower part of the casting on which the motor and compressing unit are mounted. The paint container is of 1-qt. capacity. The motor is controlled by a trigger switch in the handle of the outfit.

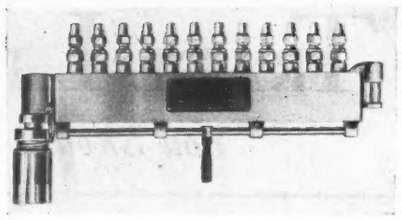
This spraying outfit is designed to operate from any light socket and, according to the manufacturer, will spray practically any liquid without thinning. It is not intended to take the place of the large paint-spraying outfits for large work, but has been designed to handle the wide variety of small painting jobs that come up around an industrial plant.

Multiple Feed Oiler

SEVERAL new features of design are embodied in the multiple-lead, wick-feed oiler that has been placed on the market by Gits Bros. Manufacturing Company, 1940 South Kilbourn Ave., Chicago, Ill. The body of the oiler is of polished aluminum and standard brass fittings are used throughout.

The oil level in the reservoir is shown in a glass sight gage. When the reservoir is filled to capacity, the valve stems inside also becomes filled with oil. When the hand lever on top is raised, oil flows through the valve stems and valves until the level reaches the top of the valve stems. In this manner each lead drains sufficient oil to flush the corresponding bearing.

After this capillary action through the wick produces a continuous flow of oil



Gits Multiple-Feed Oiler

to the bearings until the hand lever is pushed down, to close the valves.

If certain bearings require more lubrication than others, several wicks may be used in each valve stem, or two or more leads may be connected to these bearings.

It is claimed that inasmuch as dirt and sediment cannot feed through the wick, the bearings always receive clean oil.

Starters for D.C. Motors

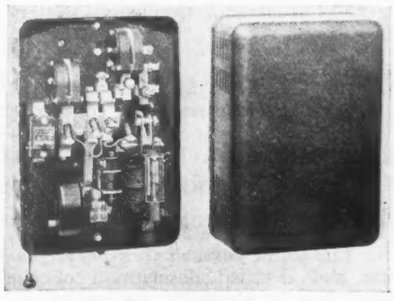
COMPLETION of a new line of d.c. motor starters for general-purpose applications has been announced by the General Electric Company, Schenectady, N. Y. These starters are designed to provide definite-time acceleration for constant- and adjustable-speed motors, and are divided into five types bearing the designations CR-4065, CR-4066, CR-4166, CR-4068 and CR-4168.

One of the principal advantages of the new design is the fact that, despite a reduction in size, the number of accelerating points has been increased, it is stated.

The CR-4065 starter is a constant-speed type for general-purpose applications, and the CR-4066 is the same type with the addition of dynamic braking. The CR-4166 is an adjustable-speed type with dynamic braking and full-field features. The CR-4068 is a constant-speed type, reversing, with dynamic braking. The CR-4168 is an adjustable-speed type, reversing, with dynamic braking and full-field features.

Thermal overload protection is provided by means of single-coil relays designed for overload protection and having a thermal capacity to stand high inrush currents. It is claimed, that these relays operate only under extreme conditions and serve as a warning to the operator that the motor or wiring requires attention.

General Electric CR-4166 Automatic D.C. Motor Starter



TRADE LITERATURE

You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

LUBRICANTS — Several interesting facts about motor oils and Houghton products in particular are contained in a new booklet by Charles E. Carpenter. —E. F. Houghton & Company, Box 6913, N. Philadelphia, Pa.

LIGHTING—Booklet No. 600, recently issued, explains several fundamental requirements for lighting the gasoline filling station.—Holophane Company, Inc., 342 Madison Ave., New York, N. Y.

FLOORS—"Plain Talk About Concrete Floors" is the self-explanatory title of a new 28-page booklet recently published.—The Master Builders Company, 7016 Euclid Ave., Cleveland, Ohio.

MOTORS—Bulletin No. 102, according to its cover, contains a general description of the various types, the advantages of each, and the method of manufacture of American electric motors.—American Electric Motor Company, Cedarburg, Wis.

FLEXIBLE SHAFTS—Catalog No. 24 contains 48 pages devoted to a description of Strand Flexible Shaft and equipment.—N. A. Strand & Company, 5001-5009 No. Lincoln St., Chicago, Ill.

MOTOR MAINTENANCE—Catalog No. 10, describes the Martindale line of motor maintenance equipment and accessories.—The Martindale Electric Company, 1260 West 4th Street, Cleveland, Ohio.

SPEED REDUCERS—The new No. 8, 16-page book describes completely the line of W. H. S. speed reducers, hangers, pillow blocks and other light power transmission machinery.—Winfield H. Smith, Springville, N. Y.

GAGES—Catalog 1800 contains 31 pages on Bristol recording liquid level gages.—The Bristol Company, Waterbury, Conn.

MOTORS—Bulletin 506 covers the L. A. single-phase squirrel cage condenser motor, a new development of this company.—The Louis Allis Company, Milwaukee, Wis.

INSTRUMENTS—Catalog No. 16 contains 112 pages devoted to a very complete and detailed description of the Jewell line of electrical measuring instruments.—Jewell Electrical Instrument Company, 1640-50 Walnut St., Chicago, Ill.

ELECTRIC RAILWAY DEVICES—A new and complete catalog supplement has just been published containing a description of 28 new mining and electric railway devices.—Ohio Brass Company, Mansfield, Ohio.

FUSES—The recently issued Bulletin 206-B, describing Trico "Powder Packed" renewable fuses, contains some interesting engineering data and tests on overload time-lag, and watt loss saving.—Trico Fuse Manufacturing Company, Milwaukee, Wis.

MOTORS—Form 663 describes the Century direct current motor, the most recent addition to this line.—Century Electric Company, 1806 Pine St., Louis, Mo.

AIR PREHEATER — Many recent changes in design are incorporated in the new catalog AH-3, describing the C-E Air Preheater.—Combustion Engineering Company, 200 Madison Ave., New York, N. Y.

AIR COMPRESSORS—"Speed up with Air" is the title of the booklet illustrating and describing a number of applications of Sullivan air compressors and tools.—Sullivan Machinery Company, 122 So. Michigan Ave., Chicago, Ill.

ASBESTOS COVERED WIRE—A series of bulletins covering the different types of asbestos insulated wires and cables has been announced by the manufacturer.—The Rockbestos Products Corporation, New Haven, Conn.

VARIABLE SPEED TRANSMISSION—The new catalog No. 88 contains 64 pages devoted to the design, construction and operation of the new Reeves variable speed transmission. — Reeves Pulley Company, Columbus, Ind.

CARBIC LIGHT — Specifications and some of the uses of the portable Carbic Light are given in a recently issued folder.—Oxweld Acetylene Company, Carbide and Carbon Bldg., New York, N. Y.

HERRINGBONE GEARS—A new 24-page catalog gives a description of an improved method of generating herringbone gears. It shows tooth forms, dimensions, price lists in cast iron and steel for recommended face widths, and hp. tables for open gearing.—W. A. Jones Foundry & Machine Company, Chicago, Ill.

AUTOMATIC CONTROL—Bulletin No. 110 illustrates numerous applications of automatic control equipment on production machines. — Monitor Controller Company, Baltimore, Md.

CUTOUTS—Folder GEA 969 describes a new line of primary cutouts manufactured by the company.—General Electric Company, Schenectady, N. Y.

AIR CONDITIONER—A folder recently issued announces the Carrier Unit Air Conditioner.—Carrier Engineering Corporation, Newark, N. J.

BELT DRESSING — A new 12-page booklet, just published contains much information on the proper care of belts. —E. F. Houghton & Company, Philadelphia, Pa.

PULVERIZER—Bulletin No. 9 describes the Grindle multi-stage unit coal pulverizer.—Grindle Fuel Equipment Company, Harvey, Ill.

MOTOR GENERATOR SETS — Bulletin No. 450 is a listing of the various sizes of generator sets, including the new two-bearing sets developed by this company. —Roth Brothers & Company, 1400 W. Adams St., Chicago, Ill.

PORTABLE LOADER—Catalog No. 428 covers the Haiss Fordson "traxion chassis" and bucket loaders.—George Haiss Manufacturing Company, 141st to 144th Sts. on Canal Place, Park and Rider Aves., New York, N. Y.

DIESEL ENGINES—A set of books has just been prepared on Diesel-Electric drive and its many marine applications, and motors and control equipment for above and below decks.—General Electric Company, Schenectady, N. Y.

DUST RECOVERY—Bulletin No. 3 contains the results of a recent survey of dust explosions and the discovery of the hazards existent in numerous chemical engineering industries.—The Dust Recovering & Conveying Company, Harvard Avenue and E. 116th St., Cleveland, Ohio.

UNIT HEATERS — A booklet entitled "How to Cut Heating Costs" explains the "Trane System of Unit Heating." —The Trane Company, LaCrosse, Wisc.

AIR COMPRESSORS—"100 and 1 Ways to Save Money With Portable Compressors" is the title of a book recently issued. In the book the company has embodied comparative cost data on its portable air compressors and air-operated tools. This information is in handy-reference, cross-index form.—Ingersoll-Rand Company, 11 Broadway, New York, N. Y.